Engineering Library

JAN 9 1931

The Engineer.

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VOL. CL.—No. 3910] LONDON: FRIDAY EVENING, DECEMBER 19, 1930 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

HEATING.

The Commissioners of His Majesty's Works, &c., are prepared to receive TENDERS before 11 a.m. on Tuesday, 13th January, 1931, for LOW-PRESSURE HOT WATER HEATING, &c., at the Telephone Exchange, Purley, Surrey.

Drawings, specification, a copy of the conditions and form of contract, bills of quantities and forms for Tender may be obtained from the CONTRACTS BRANCH, H.M. Office of Works, King Charles-street, London, S.W. 1, on payment of One Guinea. (Cheques payable to the Commissioners, H.M. Office of Works.) The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. 6237

The Director-General, India Store Department, Belvedere-road, Lambeth, London, S.E. 1, invites TENDERS for :—

SCHEDULE 1.—120 PAIRS WHEELS and AXLES for CARRIAGES and WAGONS.

SCHEDULE 2.—200 TONS of SPRING STEEL.

SCHEDULE 3.—BOGIE TRUCKS, BUFFING and DRAW GEAR, and other PARTS for ROLLING STOCK.

SCHEDULE 4.—CYLINDERS and MOTION PARTS for CONVERSION of 40 BOILERS.

Tenders due as follows :—

Schedules 1 and 2, 2nd January, 1931, at the India Store Dept.

Schedule 3, 6th January, 1931, at the India Store Dept.

Schedule 4, Tenders to be submitted direct to the Agent, North-Western Railway, Lahore, India, to arrive not later than 2 p.m. on the 29th January, 1931.

Forms of Tender for all Schedules available from the Director-General, India Store Department, at a fee (which will not be returned) of 5s. for each Schedule. 6244

Crown Agents for the COLONIES.

COLONIAL GOVERNMENT APPOINTMENTS.

APPLICATIONS from qualified candidates are INVITED for the following POST :—

M/2563.—ENGINEER REQUIRED by the GOVERNMENT of PALESTINE for appointment as CHIEF ASSISTANT ENGINEER on the Construction of the Haifa Harbour, for two years' service. Salary £1200 to £1500 a year, according to experience and qualifications. Free quarters and passages. Candidates, aged 38 to 50, must be qualified Civil Engineers and have had extensive experience on large Public Works, preferably on Harbour Construction involving Quarry Work.

Apply at once by letter, stating age, whether married or single, and full particulars of qualifications and experience, and mentioning this paper, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/2563. 6252

Royal Air Force Educational SERVICE.

APPLICATIONS are INVITED for APPOINTMENTS as CIVILIAN EDUCATION OFFICERS, Grade III., in the Royal Air Force Educational Service. Candidates will be preferred who have a Degree in Engineering. Previous teaching experience will be an advantage.

The scale of salary for Grade III. is £234-£15-£480, with an allowance varying from £60 to £100 per annum according to position on the scale. For entrants with appropriate previous experience commencing salaries up to ten increments above the minimum of the scale may be allowed. Promotion to appointments in higher grades is by selection.

Preference will be given to suitably qualified ex-Service candidates.

The form of application and a copy of the regulations for the Educational Service may be obtained from the SECRETARY, Air Ministry, Gwydyr House, Whitehall, S.W. 1. Applications should be returned not later than Saturday, 17th January, 1931. 6236

Armstrong College,

NEWCASTLE-UPON-TYNE.

(IN THE UNIVERSITY OF DURHAM.)

COURSES for the PASS DEGREE of B.Sc. and the HONOURS DEGREE of B.Sc. in MECHANICAL, MARINE, CIVIL or ELECTRICAL ENGINEERING, MINING, METALLURGY, or NAVAL ARCHITECTURE. The curricula of the Pass Degree and the Honours Degree normally occupy periods of three and four years respectively, but candidates presenting evidence of sufficient previous training may be allowed to proceed to either Degree after two years' residence.

The engineering laboratories have recently been extended, and all Departments are equipped for advanced tutorial and research work.

Full particulars of the Courses may be had on application to

THE REGISTRAR,
Armstrong College,
6105 Newcastle-upon-Tyne.

In the High Court of Justice 1930 J. 043
Chancery Division
Mr. Justice Bennett
In the Matter of J. W. and C. J. PHILLIPS, Limited,
and
In the Matter of the COMPANIES ACT 1929.

Notice is Hereby Given that the Order of the High Court of Justice, Chancery Division, dated the 19th day of November, 1930, confirming the reduction of capital of the above-named Company from £15,000 to £11,000, and the Minute approved by the Court showing with respect to the share capital of the Company the several particulars required by the above Act, were registered by the Registrar of Companies on the 6th day of December, 1930.

Dated this 17th day of December, 1930.
STONEHAM and SONS,
108A, Cannon-street, London, E.C. 4,
Solicitors for the Company. 6241

The Engineer

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PUBLIC NOTICES

Bombay, Baroda and Central INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 2nd January, TENDERS for the SUPPLY of : SPRING STEEL.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 10s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices : The White Mansion,
91, Petty France, Westminster, S.W. 1,
17th December, 1930. 6243

Manchester Corporation.

The Rivers Committee invite TENDERS for the CONSTRUCTION of MAIN DRAINAGE WORK No. 14 (New Sewer, Moston-lane, from Work No. 5, Rochdale-road to Blue Bell-avenue, Moston).

Plans may be seen and specifications, bills of quantities and forms of Tender obtained on application at the City Engineer's Office, Town Hall, Manchester, on payment to the City Treasurer of £5 5s., which sum will, after the Corporation have come to a decision upon the Tenders received, but not before, be returned to the person submitting a bona fide Tender.

All cheques or postal orders are to be made payable to the order of "The Corporation of Manchester."

Tenders, enclosed in the official envelope and addressed to the Chairman of the Rivers Committee, are to be delivered at the City Engineer's Office not later than 9.30 a.m. on Tuesday, the 30th December, 1930.

The Corporation do not bind themselves to accept the lowest or any Tender.

F. E. WARBRECK HOWELL,
Town Clerk.

Town Hall, Manchester,
6th December, 1930. 6205

PUBLIC NOTICES

High Wycombe.
BOROUGH OF CHEPPING WYCOMBE WATERWORKS.
NEW WELL AND BORING.

TENDERS are INVITED for the WORK of SINKING a WELL, 7ft. in diameter, with a BORING 42in. in diameter, into the chalk formation to a depth of 200ft. from the surface ; LINING it with CAST IRON CYLINDERS and STEEL TUBES to a depth of 90ft. from the surface, and TESTING its YIELD at the rate of 150,000 gallons an hour.

Specification and form of Tender may be obtained at the office of Mr. W. Vaux Graham, M. Inst. C.E., 5, Queen Anne's-gate, Westminster, S.W. 1, the Consulting Engineer to the Corporation (on and after Tuesday, December 16th), on payment of Two Guineas, which will be returned on receipt of a bona fide Tender.

Sealed Tenders, endorsed "Tender for Well and Boring," to be delivered to the undersigned not later than first post on Wednesday, January 7th, 1931.

The Corporation do not bind themselves to accept the lowest or any Tender.

S. YOUNG,
Engineer and Manager.

71, Easton-street,
High Wycombe, Bucks. 6245

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

EDUCATED MAN REQUIRED by Old-established Manufacturing Firm, with practical and commercial engineering knowledge. Age about 25 years. Commencing salary £300.—Address, P611, The Engineer Office. P611 A

XMAS HOLIDAYS.

All Advertisements intended for the Classified Advertisement Section of December 26th issue must reach this office not later than first post Tuesday, December 23rd.

28, ESSEX STREET, STRAND, W.C. 2.

PUBLIC NOTICES

City of Westminster.
PUBLIC BATHS AND WASHHOUSES.
RESIDENT ENGINEER.

The City Council invite APPLICATIONS from persons not over 40 years of age for the POSITION of RESIDENT ENGINEER at their Public Baths and Washhouses in Buckingham Palace-road, S.W. 1.

The wages attaching to the position are £3 12s. per week with apartments, light and fuel (valued for the purposes of pension at £50 per annum).

Applicants must possess a practical knowledge of Steam Boilers, all Mechanical Laundry Plant, Water Filtration Plant and Chemical Treatment of Water connected therewith, and be able to carry out maintenance repairs. The successful applicant will be required to control the establishment in the absence of the General Superintendent, to whom he will be directly responsible.

He will also be required to pass a medical examination as to his physical fitness to carry out the duties of the position, and to subscribe to the City Council's Pension Fund.

Applications, accompanied by three recent testimonials, must be made on forms which are obtainable from the undersigned, to whom they must be returned not later than the 31st December, 1930.

PARKER MORRIS,
Town Clerk.

Westminster City Hall,
Charing Cross-road, W.C. 2,
12th December, 1930. 6233

SITUATIONS OPEN (continued)

WANTED, CONTRACTOR'S ENGINEER, Experienced in Railway Construction.—Address, 6248, The Engineer Office, stating experience, age and salary required. 6248 A

WANTED, for Eastern Service, Young ENGINEER with Saw Milling experience, including Band Saws.—Write, Box "M.V.P.," c/o Davies and Co., 95, Bishopsgate, E.C. 2. P608 A

ENGINE DESIGNER REQUIRED, with Experience in Compression Ignition for Automobile Work ; capable of developing new design. Chassis experience an advantage. State age, salary and full particulars.—Address, 6254, The Engineer Office. 6254 A

LARGE and Old-established ENGINEERING COMPANY with Foundry and Machine Shops equipped to produce General (Heavy) Machinery, is OPEN to APPOINT an ENGINEER as SALES REPRESENTATIVE for the London district.

Entree to users and shippers of Sugar, Chemical, and Colliery Machinery essential. Position remunerated chiefly by commission, but good prospects for right man.

Address, P609, The Engineer Office. P609 A

MANAGER, with First-class Experience for Siemens Acid Open-hearth Plant, three 20-ton furnaces.—Write in confidence, stating specifically age, full details of experience, when disengaged, and salary required, to GENERAL MANAGER, Andrews Toledo, Ltd., Toledo Steel Works, Sheffield. 6253 A

PLANT LAY-OUT and TOOL DRAUGHTSMEN WANTED for Automobile Factory.—Address, stating age, salary required and full details of experience, 6249, The Engineer Office. 6249 A

STRUCTURAL DRAUGHTSMAN REQUIRED for London office, accustomed to preparing Shop Details for Steel-framed Buildings under L.C.C. 1909 Act. State age, experience in detail and salary required.—Address, 6240, The Engineer Office. 6240 A

STRUCTURAL ENGINEER and DRAUGHTSMAN WANTED by a N.W. London Firm of Structural Engineers. Must be accustomed to interviewing clients and assisting with supervision of outside erection. Only those with similar experience need apply, stating salary, &c.—Address, 6242, The Engineer Office. 6242 A

REQUIRED for India, Skilled FOREMAN on Hydraulic Press Work for Tank Plates, Trough Plates and Wagon Pressings. Aged about 30 ; must have held similar position here. Agreement five years. Applicants must give fullest deatils of education, training, work done, present position and salary, stating whether married or single.—Write, ZX907, c/o Deacon's Advertising Agency, Fenchurch-avenue, London. 6235 A

SITUATIONS WANTED

CONTRACTOR'S ENGINEER (32), 11 Years' Exp. with famous firms on construction of large works, home and abroad, in very responsible capacity, SEEKS EXPERIENCE with Civil Engineering Firm where knowledge of costs and contractors' methods may be of use.—Address, P614, The Engineer Office. P614 B

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SHEFFIELD.—Steel, Files, Saws, Magnets. ADVERTISER, full knowledge of the trade and important connection, DESIRES APPOINTMENT, London and 20 miles radius.—R. H., 98, Wormholt-road, W. 12. P613 B

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FOUNDRY FOREMAN SEEKS POST; Experienced turbine, Diesel, Fullagar oil engines, general jobbing, &c., loam, green and dry. Excellent refs. Age 39.—Address, P612, The Engineer Office. P612 B

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76, Temple Bar House, London, E.C.4.
(*Founded* 1917.)

PATENTS

BRITISH PATENT 281,621, for "Manufacture of Steel." FOR SALE or LICENCE.—Further particulars apply, CHATWIN and COMPANY, 253, Gray's Inn-road, London, W.C. 1. P607 H

BRITISH PATENT 262,753, "Heating by Oil Circulation." FOR SALE or LICENCE.—Further particulars apply, CHATWIN and COMPANY, 253, Gray's Inn-road, London, W.C. 1. P606 H

INTERNAL COMBUSTION TURBINE; COMPRESSION GREATER than present type engine. Size one-half, power twice, cost one-tenth. INVENTOR wishes to EXPLOIT above. Practical; no exaggeration.—Address, P583, The Engineer Office. P583 H

KING'S PATENT AGENCY, Ltd. (B. T. KING, Regd. Patent Agent G.B., U.S., and Can.), Advice handbook and consultations on Patents and Trade Marks FREE.—146A, Queen Victoria-street, London, E.C. 4. 43 years' ref. 'Phone: Central 0682. 5839 H

THE PROPRIETORS of BRITISH PATENTS Nos. 7089/15, 153,867 and 194,201, relating to "Roller Bearings;" and No. 203,472, relating to "Machines for Gauging and Sorting Bearing Rollers," are DESIROUS of ENTERING into ARRANGEMENTS with British Manufacturers with a view to the SALE or COMMERCIAL EXPLOITATION of the inventions protected by the said patents.
Interested parties are invited to communicate with the undersigned for further particulars.
H. N. and W. S. SKERRETT, 24, Temple-row, Birmingham. 6239 H

THE PROPRIETOR of BRITISH PATENT No. 282,972, dated 20th December, 1926, relating to "Weighing Devices," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patent and ensuring its practical working in Great Britain.—All inquiries to be addressed to B. SINGER, Steger Building, Chicago, Illinois. 6234 H

PATENTS, "IMPROVEMENTS IN TUBE COUPLINGS."

THE PROPRIETORS of Mr. A. La Rue-Parker's BRITISH PATENT No. 282,210 are DESIROUS of LICENSING the PATENT to British Manufacturers to ensure its use and development, or of SELLING the PATENT outright.
For full information address enquiries to W. P. THOMPSON and CO., Chartered Patent and Trade Mark Agents, 12, Church-street, Liverpool. P603 H

THE PROPRIETOR of LETTERS PATENT No. 282,681, relating to "Improvements in or relating to Centrifugal Apparatus for the Separation of Suspended Particles in a Liquid," DESIRES to DISPOSE of the PATENT or to GRANT LICENCES to interested parties at reasonable terms with a view to the adequate working of the patent in Great Britain.
Inquiries to be addressed to—
BOLAGET VINKELCENTRIFUG,
Kungsgatan 51,
6250 H Stockholm, Sweden.

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AGENCIES

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FRANCE.—The PROPRIETOR of a Scientific Research Organisation with extensive industrial connection, well introduced to libraries and educational establishments, WISHES to SECURE EXCLUSIVE AGENCIES for Representing Manufacturers of Measuring Instruments and Scientific Apparatus for laboratories, technical colleges, &c. Would also undertake to stoke English technical publications.
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AGENCIES

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MISCELLANEOUS

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The British Institute of Engineering Technology, 22, Shakespeare House, 29-31, Oxford Street, W. 1.
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FOR SALE

GALVANISED CORRUGATED SHEETS.—Large stocks, 5ft. and 6ft. long, 18/22-gauge; £11 per ton.—JAMES SUMMERHILL and CO., Ltd., No. 9 Dept., Beaver Works, Wolverhampton. 6194 G

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HERBERT No. 1 Hexagon Turret Lathe. At LINCOLN.
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VAN NORMAN No. 3 Duplex Miller. At STOKE-ON-TRENT.
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For continuation of For Sale Advertisements see page 80.

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A Seven-Day Journal

Depth Sounding at Sea.

FOLLOWING the recommendation of the Safety of Life at Sea Convention that the contracting Governments should encourage the development and use of depth sounding apparatus on the reflection principle, the Marconi Company experimented with various types of apparatus designed for the purpose and eventually selected the well-known Langevin-Chilowsky process, which it has elaborated to suit the requirements of the British merchant navy. In order to obtain the best available information on the subject the assistance of Professor Langevin and his colleagues was obtained, and Professor Langevin has consented to take a seat on the board of directors of the new company, which owns world-wide rights for the patents. The Marconi sounding device takes accurate soundings directly underneath the ship and is set in action by pressing a button on the ship's bridge. On the button being pressed the apparatus immediately shows the depth of the water under the ship by means of a pointer which moves over the surface of a scale and remains stationary for about ten seconds at the correct depth. The operation is repeated four times a minute until the apparatus is switched off. The working of the device is independent of the speed at which the ship is travelling and, being automatic, it requires no human skill to operate it. Its principle involves the transmission of a high-frequency electrical impulse from the bottom of the ship to the ocean bed, from which it is reflected back to the transmitting source and, as the speed of such a signal through water is known, the depth is arrived at from the time taken for the signal to travel to the ocean bed and back again to its source.

Electricity in the Irish Free State.

ADDRESSING a recent meeting of the Dublin Rotary Club, Dr. T. Maclaughlin, the managing director of the Shannon Electricity Supply Board, outlined the progress that had been made in the electrification of the Free State since the completion of the Shannon water power scheme. Within a period of fourteen months, Dr. Maclaughlin explained, a measure of success had been achieved which had not been expected for at least two years. Already about 100 towns and villages had their streets lit with current supplied by the Shannon power station. There had also been a marked advance in the use of electricity for domestic purposes, as no fewer than 900 electric ranges had been sold, and there was a growing demand for all kinds of electrical appliances. Ford's factory at Cork and the large plant of Messrs. Pierce at Wexford were run entirely on the Shannon current, which was also used for working the tramways in Dublin and Cork.

The Fulham Power Station.

ON Monday, December 15th, the public inquiry into the application of the Fulham Borough Council for consent to extend its generating station in Townmead-road, Fulham, was opened by the Electricity Commissioners at the headquarters of the Institution of Electrical Engineers. The application is opposed by the London County Council and other local authorities and by various societies and individuals. In a letter the trustees of the National Gallery referred to their previous protest against the erection of the Battersea power station and described the new proposal as a serious aggravation of the danger to works of art. The London Society also submitted a letter of protest, signed by a number of societies. Mr. Tyldesley Jones, opening the case for the applicants, said that if he were right in the submission that a modern generating station could be designed and worked so as to avoid the emission of sulphur dioxide, the sooner such a station was erected and brought into use the better, as there was a large number of existing stations in which it would be difficult to employ the methods available for preventing the nuisance. The engineers who would give evidence were satisfied that the chemists' solution of the problem—washing the flue gas—was the right one. The apparatus at Fulham worked on the principle of bringing the gas into contact with water by a different method from that adopted at Battersea. The apparatus could be seen in operation and he hoped that the Commissioners would take the opportunity of inspecting it.

Yarrow and Company, Ltd.

AT the ninth annual meeting of Yarrow and Co., Ltd., which was held at Scotstoun, Glasgow, on Monday last, December 15th, Mr. Harold E. Yarrow, the chairman of the company, stated that in spite of the difficult times and the keen competition, the directors were able to recommend a payment of 5 per cent. on the ordinary shares of the company. Referring to the continued adoption of the Yarrow boiler for both land and marine work, Mr. Yarrow announced that the Cunard Steamship Company had decided to install the latest type of high-pressure Yarrow boilers in its new express liner which is being built at the Clydebank yard of John Brown and Co., Ltd. The boilers will be constructed by the builders of the ship, to designs which Yarrow and Co. are now preparing. Continuing his review of the year's work, Mr. Yarrow referred to the success of the Dutch destroyers built to the firm's designs, and to the gunboats constructed at Scotstoun for the Colombian Government, which, he said, had safely arrived at their destination, and were now in service. Brief mention was also made of the firm's new interest in the Yugoslavian shipyard at Kraljevica, and the large flotilla leader which is being laid down at Scotstoun for the Yugoslavian Government. As regards marine boiler work, the firm has undertaken to supply a 1000 lb. pressure boiler for the Imperial Japanese Railways, and it has several boilers in hand for the British mercantile marine. During the year the high-pressure Yarrow boiler designed in conjunction with Mr. H. N. Gresley, chief mechanical engineer of the London and North-Eastern Railway Company, for the locomotive No. 10,000, has given good results in service. The boiler shops will be well occupied for some months to come on both marine boilers and ten high-pressure land boilers for the Greenwich power station. Following the policy laid down by Sir Alfred Yarrow, the firm is continuing to carry out experimental work in various directions.

A Large Atlantic Liner for France.

IN a Journal note in our issue of August 29th last we made a short reference to the new express liner for the Compagnie Générale Transatlantique, which is to be built at the Penhoet shipyard at St. Nazaire for Atlantic service. The reported length of the ship proposed is about 1000ft., with a displacement of 65,000 to 75,000 tons, and it is understood that a service speed of something over 30 knots is to be aimed at. The propelling machinery will most likely be a four-screw arrangement with turbines designed to develop over 150,000 shaft horse-power. The direct turbine drive, which was successfully adopted in the company's latest large liner the "Ile de France," is said to be favoured, but, on the other hand, the turbo-electric drive will probably be considered on account of the very quiet running associated with this system of propulsion. It is generally understood that the preliminary questions relating to the construction have been satisfactorily settled, and that work on the ship has been begun. Special interest attaches to this liner in view of the progress which is being made with the building of our own Cunard liner. The boilers for the new Cunarder are referred to elsewhere in these columns, and it is also probable that high-pressure water-tube boilers will be favoured for the French liner.

New Naval Contracts.

A DEPUTATION of the Shipbuilding Employers' Federation recently waited upon the First Lord of the Admiralty, Mr. A. V. Alexander, to point out the distress in all shipbuilding districts, and to press for as wide a distribution as possible of the naval construction work which is to be carried out under the present year's programme. The Government has now decided, at the suggestion of Mr. Alexander, to allocate the work as follows:—One cruiser, with machinery, is to be built at Cammell Laird's Birkenhead yard. Two destroyers and one set of cruiser machinery will be constructed at Vickers' yard at Barrow-in-Furness. The Clyde and Tyne yards will be responsible for two destroyers and one set of machinery each; Fairfields will construct two destroyers, and Beardmores the machinery for the dockyard flotilla leader, while at Wallsend Parsons will supply machinery for a dockyard-built cruiser, and Palmers are to construct two destroyers at Jarrow; and two destroyers are to be built by Thornycrofts. The total cost of the whole programme, including the cruiser and flotilla leader to be built at Portsmouth, the cruiser and three sloops at Devonport Dockyard, and the two small submarines and a net-layer at Chatham Dockyard, is estimated to amount to £9,500,000. Of this sum nearly £5,000,000 is accounted for by the orders which are to be placed with private yards, as above outlined, and the materials required for the dockyard ships. The Government has decided that the signing of the London Naval Treaty, with the consequent limitation of the number of ships to be built in the next five years, provides an opportunity for stabilising the amount of naval shipbuilding allocated to each successive year, and it is understood that the 1930 programmes and for the succeeding year have been drawn up on that basis. The work on the programme for the present financial year is not expected to be begun before February next.

Co-operative Profit-Sharing.

DETAILED statistics have been issued by the Co-operative Productive Federation showing the progress of the federated societies during the year 1929. In the section relating to the metal-working and miscellaneous industries are four societies having an engineering interest. Judged by the financial results, Walsall Locks and Cart Gear, Ltd., had the most successful year's trading. At the end of 1929 this Society had 335 members, with a share and loan capital of £24,453. There were 338 workpeople, and the wages bill amounted to £36,845. The business done totalled £77,922, showing a net surplus of £2926. In 1928 the figures were £83,747 and £3596 respectively. Of this surplus, £82 went to capital, giving a bonus of 6¼ per cent.; £1786, or 1s. 3d. in the pound on wages, to the employees, and £206 to educational and charitable purposes. Of the remaining engineering societies, one reported a deficit and two made a surplus at the end of the twelve months. Neither society, however, declared any bonus. The Alcester Needle Makers, Ltd., had a membership of 146 and a share capital of £1694. Its sales totalled £16,165, giving a net surplus of £229. The wages of its 14 employees amounted to £2062. Chesham Builders, Ltd., with a membership of 43, had a capital of £793. A turnover of £9814 gave a surplus of £35. It had 28 employees and its wages bill amounted to £4477. The Leicester Carriage Builders, Ltd., returned 181 members and a share and loan capital of £7352. Business, which amounted to £12,974, resulted in a deficit of £672. The wages bill totalled £5278, and there were 40 workpeople at the end of the year. A total of 43 societies is included in the Federation's survey. Together, there were 15,690 members and a share and loan capital of just over a million pounds. The sales amounted to nearly three millions, and gave a net aggregate surplus, after deducting deficiencies, of £150,495. There were 6998 employees and a wages bill of £757,495. In the distribution of the surplus, capital received £8191, labour £34,903, and purchasers £60,122, while the sum of £5012 was allocated to grants for educational and other charitable purposes.

The National Experimental Tank.

AT the meeting of the Executive Committee of the National Physical Laboratory on December 16th, with the approval of the Tank Advisory Committee, it was decided that, in view of the expansion of the National Experimental Tank Department, it should, in future, be called the "William Froude Laboratory"; that the existing experimental waterway should be called the "Alfred Yarrow Tank," and the waterway now under construction "The New Tank." In this way, whilst still doing honour to William Froude, the father of modern test work in ship propulsion, the Committee has expressed its appreciation of the munificence of Sir Alfred Yarrow in the establishment of the tank, and his great interest in its work during the 20 years it has been in existence. Some such step was inevitable in the near future to save confusion. Because of the great difference in the dimensions of the two testing tanks, it will be necessary in any description of research work, to make it clear in which tank the experimental work was done. The Yarrow tank was opened officially by the Marquis of Bristol in July, 1911. For nearly ten years now, the tank has been working continuous overtime in order to cope with the increasing volume of work. The difficulties in dealing with the work eventually led to such delays that representations were made to the Government by the London and Liverpool Chambers of Shipping, urging the importance of increasing the facilities for tests. In February this year, Mr. J. H. Thomas, the then Lord Privy Seal, announced that a new tank was to be built, and a start has now been made on the construction of that tank. Since the Yarrow tank was completed, new tanks for mercantile ship work have been constructed, or are being constructed at Vienna and in Japan, Italy and Holland, and a very large tank available for any tests is under construction in the United States of America.

Mr. J. F. Gairns.

WE regret to have to record the sudden death of Mr. John Francis Gairns, a well-known writer on railway subjects. Mr. Gairns left his office in apparently the best of health and, as usual, full of cheerfulness, on the afternoon of Tuesday, December 9th, but was taken ill at midnight and died three hours later. Mr. Gairns had more than the customery schoolboy knowledge of locomotives, when, as a youth of eighteen years, he joined the firm of Wheatley and MacKenzie, patent agents, with whom he remained for some years. Gradually drifting into locomotive literature, his acceptable pen brought him a position on the *Railway Magazine*, of which paper he was appointed editor in 1910. About that time he became associated with *Railway News*, and when that paper was incorporated with the *Railway Gazette* in 1918, his services also were transferred to the latter journal, of which he subsequently rose to be assistant managing editor. A subsidiary publication of the *Railway Magazine* is the *Railway Year Book*, and of that Mr. Gairns was also the editor and therein showed his ready ability to acquire and to distribute information. Mr. Gairns wrote three books. The first was "Locomotive Compounding and Superheating" (Griffin); the second "Locomotive Superheating and Feed Water Heating" (Locomotive Publishing Company), of which the third edition appeared in 1926, and the third, "Railways for All" (Ward, Lock), a popular book. He was very active in the meetings and welfare of the Railway Club, and was a member of the Institution of Locomotive Engineers and of the Institute of Transport. He was a hard worker, very observant, always accessible, and ever ready to help an inquirer. He will be much missed from the small band of ready writers on railway questions, and his loss at the early age of fifty-four will be deeply regretted.

The Manufacture of S.A.A. Cartridge Cases.

By F. ADCOCK, M.Sc., Ph.D., A.M.I. Mech. E., Chartered Mechanical Engineer.

No. I.

SUMMARY.

THE article is divided into three parts, the first part dealing with the production of strip, the second with the production of cups, and the third with the remaining operations. The cup stage marks a definite point of division in the process, as a considerable export trade in cups exists.

The production of accurate strip is most essential in cartridge work, and methods of doing this are described.

In the operations of blanking and cupping, British and continental methods are at variance. Both methods are described and discussed.

In a multiple punch machine the requisite punch and die diameters are not necessarily equal. The reasons for this are fully investigated, and a complete theory of the flow of metal during the operation of blanking is enunciated.

The effects of contour of cupping die on base thickness, &c., of the cups produced are described.

Rules are given for the determination of the necessary strip thickness and the dimensions of the tools to make cups to a given specification.

The operations subsequent to cupping are chiefly drawing, indenting, and heading. The drawing operations are usually five in number.

In drawing, the base of the product usually thickens. The factors which influence this thickening are discussed, and rules for determining the strip thickness and the dimensions of the tools necessary to make cases to a given specification are formulated.

The operation of indenting is the most difficult, as a fold is liable to develop unless steps are taken to prevent it. The method of doing this is described.

PART I.—UP TO THE STRIP STAGE.

THE METAL.

The metal from which cartridge cases are made is usually a brass with a copper content of from 65 to 75 per cent., and as pure as possible. The following is a typical chemical specification indicating the way in which the various ingredients and impurities should be specified :—

Copper	69 to 70 per cent.
Any single impurity	Not over 0·25 per cent.
Total impurities	Not over 0·5 per cent.
Remainder	Zinc

The elements usually estimated in analysis are copper, tin, lead, iron, and sometimes nickel. The remainder is then assumed to be zinc. The accuracy of the estimation of zinc is not sufficient to justify the addition of the copper and zinc figures, and assuming the remainder as impurities, the sum of the copper and zinc figures not infrequently exceeding 100 per cent.

CASTING.

In order to produce an alloy of any desired composition a charge consisting of manufacturing scrap and virgin copper and zinc is made up. The proportion of zinc in the charge is higher than that desired in the ingot on account of the loss of this constituent by volatilisation and oxidation. The amount of this loss depends on the type of furnace and should be known as accurately as possible.

The charge being weighed out in suitable proportions, the scrap is first introduced into the furnace and melted, then the copper, and when the latter has dissolved in the molten bath the zinc is added. The charge is ready for casting as soon as the zinc is completely dissolved, and is cast without delay in order to avoid undue loss of zinc.

The charge is poured into cast iron moulds previously treated with a suitable dressing.

The size of the ingot depends on the processes which have to follow, and hence cannot be discussed at this stage ; but for the process described in this paper, the size is 3½in. by 1⅝in. by 4ft.

ROLLING.

As soon as the ingots are sufficiently cool they are removed from the moulds and the upper ends are sheared off, about 3in. being removed. The ingots are then rolled down cold in a mill known as the breaking down mill in three passes to a thickness of 1in. They are then annealed at a temperature of 750 deg. Cent. for half an hour and "scalped." This process consists of removing the outer skin of scale and dirt from the two faces by a planing machine. After scalping, the ingots are rolled to a thickness of ⅜in. in three passes, annealed at a temperature of 700 deg. Cent. for half an hour and pickled in dilute sulphuric acid. Sulphuric acid has the property of dissolving the scale while not affecting the metal. By this time the strips have elongated considerably, and in order to facilitate handling each one is cut into three. The next rolling brings the strips down to finished thickness, 0·130in. to 0·160in., in three passes, after which they are annealed at a temperature of 650 deg. Cent. for half an hour, pickled and polished.

THE ACCURACY OF ROLLING.

The method of rolling having been described, a few remarks on accuracy may now be apposite. The question of accuracy is chiefly a question of rigidity of rolls. A roll deforms in two ways—first, there is the general deformation or curvature of the axis due to beam action ; and, secondly, there is the local deformation or indentation due to the contact pressure. The rolls ordinarily used for breaking down are 16in. diameter by 24in. long, for the intermediate rolling 12in. diameter by 20in. long, and for the final rolling 8in. diameter by 12in. long. It has been found that with these rolls, if the greatest possible care is taken, the strip can be rolled to an accuracy of within ±0·001in. of the desired mean thickness.

At this stage the general characteristics of strips

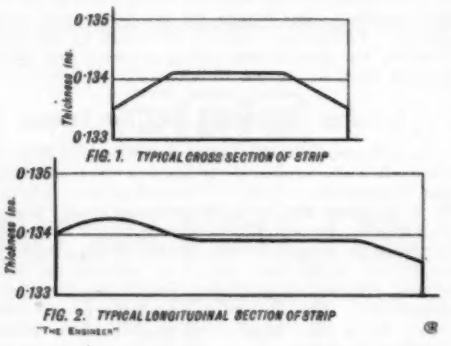


FIG. 1. TYPICAL CROSS SECTION OF STRIP

FIG. 2. TYPICAL LONGITUDINAL SECTION OF STRIP
"THE ENGINEER"

may be described. In the first place, a strip rolled with straight cylindrical rolls is not of equal thickness from edge to edge and the cross section is remarkably uniform along the length of a strip and between different strips. The characteristic shape of the cross section of a strip is shown in Fig. 1. In addition to this characteristic cross section, each strip also has a characteristic longitudinal section, as shown in Fig. 2, which shows a strip which in its last pass has been passed through the rolling mill in the direction from left to right. It must be remembered that strips are always passed in alternate directions through the mill in order to minimise the effect of this longitudinal variation, and this alternation of direction tends to give the characteristic longitudinal section its slight amount of symmetry.

When considering the variation of an observed quantity from its mean or desired value, the statistical method of plotting the results is very useful. In this system the number of readings which fall between any two values separated by a small interval is plotted as ordinate against the value of the reading as abscissa. A glance at Fig. 3 will make this clear. This shows the result of plotting 1000 measurements of the thickness of a batch of strip rolled in accordance with the procedure just described. It is obvious from the nature of this diagram that a large number of measurements must be available before it can be constructed, but, beyond a certain number, any further increase in the number of measurements does not appreciably affect the shape of the diagram. This number may be taken as about 500, though much can be learned from a diagram constructed with only 100 measurements. One great advantage of this diagram is its ability to indicate the presence of a disturbing influence, the existence of which might otherwise pass unnoticed. In general, it may be stated that if the diagram is not symmetrical a disturbing influence is to be suspected. Another advantage is its application to the comparison of the relative values of different batches of articles. Figs. 4 and 5 represent diagrams constructed from measurements taken from two batches of articles A and B. The mean value of the dimension measured is the same in both cases and the extreme variation from the mean value is also the same, but the sharper peak of the diagram in Fig. 5 indicates that batch B is superior to batch A.

To return to the question of accuracy of strip rolling, a study of the characteristic cross section shows where there is room for improvement, and this problem has been attacked in the following manner. In general, the thickness of the strip was 0·0005in. greater at the centre than at the edges, and it was hence concluded that if the strip could be given a very light rolling with rigid rolls sufficient to reduce the centre but not the edges, the strip could be made parallel in cross section. This rolling was known as "equalising," as it was not intended to effect a general reduction in thickness, but merely to reduce the high places to the level of the low ones. The results were at first somewhat disappointing, as it was found that many passes were required and then the edges of the strips were also reduced a little. Briefly, the effect of equalising may be said to have been not to reduce the total variation in thickness from centre to edge, but to increase the width of the central flat portion and to reduce the width of the tapered portions at the edges.

Up to this stage, equalising had always been conducted before the final annealing in the cases in which the strip was required in the annealed condition, but as the results appeared to show room for further improvement, experiments were conducted on equalising after annealing. This was found to be far more successful, and it was found that strip which varied ±0·001in. before equalising varied only ±0·0005in. after one pass through the equalising mill. These results were achieved by allowing a mean of 0·002in. to be reduced by the equalising rolls ; that is, if strip was required to be finished to a thickness of 0·134in. ±0·0005in. it was rolled down to 0·136in. ±0·001in. by the ordinary process and then annealed. If it can be assumed that the thickest strip before equalising remains the thickest after equalising and that the thinnest remains the thinnest, it is seen that the thickest is reduced by 0·0025in. and the thinnest by 0·0015in. with the same setting of the rolls.

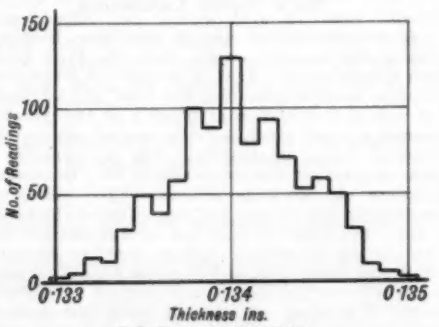


FIG. 3. ORDINARY STRIP

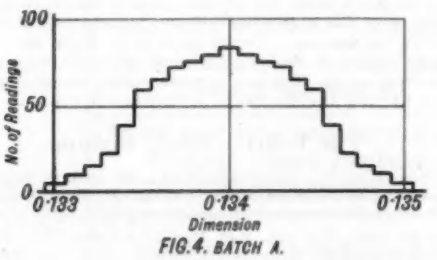
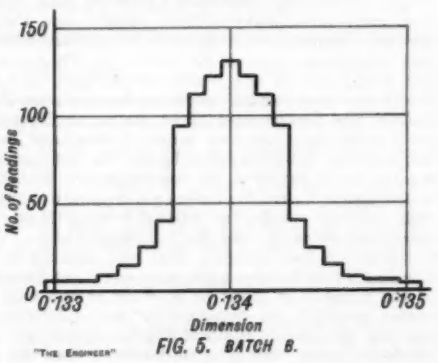


FIG. 4. BATCH A.



"THE ENGINEER" FIG. 5. BATCH B.

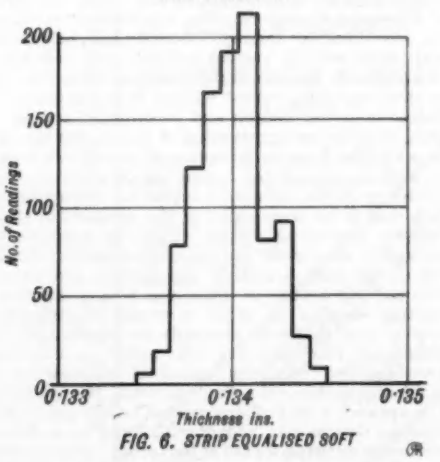


FIG. 6. STRIP EQUALISED SOFT

A typical diagram representing measurements taken on a batch of strip which has been equalised soft is shown in Fig. 6. It is seen by comparing this with Fig. 3 that the effect of equalising soft is to make the diagram taller and narrower. It should be noted that the area of the diagram is proportional to the number of measurements which have been used in its construction.

It was first suspected that equalising soft would be detrimental to the ductility of the strip, but this was found not to be the case. Whereas annealed strip had a Brinell hardness of about 62 (1000 K, 10 mm.), equalised strip was found to have Brinell hardness of about 75. This is not a great increase in hardness and does not materially affect the ductility of the metal ; in fact, cups made from equalised strip were found to

have a smoother surface and finer appearance than those made from annealed strip.

The rolls used for equalising were 18in. diameter by 6in. long, proportions which are very different from usual practice.

It may be asked, why not use collared rolls, as is done in steel strip rolling. The answer which one gets in the works is that plain rolls are better, as they can be used for rolling various widths of strip without the expense of changing rolls, but this argument is equally applicable to steel works.

PART II.—FROM THE STRIP TO THE CUP.

Blanking and Cupping.

The next process after rolling is blanking and cupping. Here, British and Continental practice find themselves at variance. Continental practice is to roll strip of width suitable for cutting one blank at a time and to cut the blanks from the strip, while it is in the hard-rolled condition. The blanks are then annealed and fed into another machine to be cupped. British practice is to roll strip sufficiently wide to cut three or four rows of blanks and to cut and cup this strip in the annealed state by means of concentric punches and combination dies in a multiple punch machine. The advantage of the Continental method is that the desired accuracy of weight and base thickness of the resulting cups is more easily attained, but by exercising every care and employing certain refinements the British method can be made to yield a product rivalling the continental in accuracy at much less cost.

Blanking.

From what has already been said about strip rolling, the attraction of narrow strip is easily understandable, as the variation in thickness from centre to edge is less detrimental; but there is another advantage in cutting only one blank at a stroke which is not immediately obvious.

It has been found that the actual weight of a blank is always less than the calculated weight of a cylinder of diameter equal to the diameter of the blanking die and of thickness equal to the thickness of the strip. This results from the plasticity of the metal allowing some metal to flow radially outwards from the blank under the influence of the axial compression before the blank is severed from the strip. When this fundamental fact has been appreciated, it is easy to understand that the amount of the loss of weight depends on the amount of resistance which the surrounding metal is capable of exerting. That is to say, a blank cut in an isolated position, a considerable distance from the edge of the strip and from a previously cut hole, will be the heaviest blank which it is possible to cut from metal of that thickness, while a blank cut in close proximity to the edge of the strip or to a previously cut hole will be lighter in weight, according to the resistance of which the surrounding metal is capable. The amount of variation in weight which can be caused by this effect is large enough in comparison with the usual working tolerances on cartridge cups to warrant special attention being devoted to it. As would be expected, the loss of weight of a blank from the calculated weight of a cylinder, diminishes as the hardness of the strip increases, and this constitutes one of the advantages of cutting blanks from hard strip and annealing the blanks instead of annealing the strip before blanking.

In the Continental method of cutting blanks one at a time, the first blank cut from a strip will be subject to the losses due to the proximity of the two edges of the strip, while all subsequent blanks will be subject to these same two losses and also to that due to the proximity of a previously cut hole. If the weight of an isolated blank be denoted by w, the loss due to an edge by e and that due to a previously cut hole by h, the weight of the first blank will be $w-2\,e$, while that of each subsequent blank will be $w-(2\,e+h)$.

When using a multiple-punch machine, the conditions under which the punches work are not the same, but depend on their position in the block and the arrangement of the positions in the block. As an example of this, one form of four punch block will be considered, the one usually adopted. The arrangement of the positions in this block will be seen from Fig. 7, which shows a strip which has been passed through the machine in the direction away from the observer. The positions are numbered by commencing at that nearest to the observer and following round in a clockwise direction.

The first blank cut in position No. 1 will be an isolated blank, and, consequently, will be of weight w, while all subsequent blanks will be subject to the influence of a previously cut hole and will, consequently, be of weight $w-h$.

The first blank cut in position No. 2 will be subject to the edge of the strip and will, consequently, be of weight $w-e$, while the second and all subsequent blanks will be subject to the influence of the edge of the strip and a previously cut hole and will, consequently, be of weight $w-(e+h)$.

The first blank cut in position No. 3 will be an isolated blank of weight w, the second will be subject to the influence of a previously cut hole and will be of weight $w-h$, the third will be subject to the influence of two previously cut holes, one in position No. 3 and one in position No. 2, and will, therefore be of weight $w-2\,h$. The fourth will be subject to the influence of one previously cut hole in position No. 3, two in position No. 2, and one in position No. 1, and will, consequently, be of weight $w-4\,h$. The fifth and all subsequent blanks will be subject to the influence of one previously cut hole in position No. 3, two in position No. 2, and two in position No. 1, and will, consequently, be of weight $w-5\,h$.

The first blank cut in position No. 4 will be subject to the influence of the edge of the strip and will be of weight $w-e$. The second will be subject to the influence of the edge of the strip and one hole, and will, consequently, be of weight $w-(e+h)$. The third will be subject to the influence of the edge of the strip and two holes, and will be of weight $w-(e+2\,h)$, while the fourth and all subsequent blanks will be subject to the influence of the edge of the strip and three holes, and will, consequently, be of weight $w-(e+3\,h)$.

Summarising these results in tabular form, the following table is constructed. The columns are arranged as the rows of blanks are arranged across the strip—

Position No.	2.	3.	1.	4.
First blank	$w-e$	w	w	$w-e$
Second blank	$w-(e+h)$	$w-h$	$w-h$	$w-(e+h)$
Third blank	,,	$w-2\,h$	,,	$w-(e+2\,h)$
Fourth blank	,,	$w-4\,h$	,,	$w-(e+3\,h)$
Fifth blank	,,	$w-5\,h$	,,	,,

It has been found experimentally that with equal width of webbing scrap between holes and edges

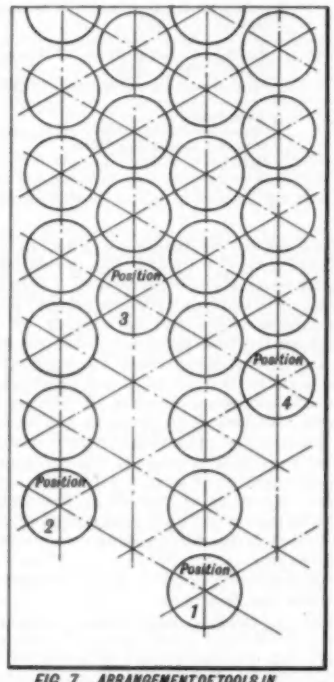


FIG. 7. ARRANGEMENT OF TOOLS IN FOUR-PUNCH BLOCK
"The Engineer"

$e=2\cdot5\,h$. Inserting this value of e in the above table, it is seen that, after a steady state has been reached, the weights of the blanks cut in the various positions are as follows :—

Position No.	Weight.
1	$w-h$
2	$w-3\cdot5\,h$
3	$w-5\,h$
4	$w-5\cdot5\,h$

It is seen that the weights are in numerical order of position, No. 1 being the heaviest and No. 4 the lightest.

Blanks for cartridge case manufacture are usually a little less than an inch in diameter, and about 200 grains in weight. A width of webbing scrap between adjacent holes and edges of the strip of about 0·1in. is adopted as the minimum safe value to avoid cutting in when the feed is a little irregular. Cutting in must here be understood to include cases in which a blank is cut sufficiently close to a previously cut hole seriously to affect its weight.

The width of webbing scrap has an important bearing on the cost of production as the efficiency of cutting, or the ratio of the weight of the blanks to the original weight of the strip from which they are cut, is rather low, namely, about 58 per cent. for a single-punch machine, and 63 per cent. for a four-punch machine. The value of the scrap per pound is about half the value of strip. The cost of re-melting and re-rolling the scrap thus amounts to a serious item in the cost of blanks.

For the purposes of investigation, blanks were collected from the various positions separately. The average for each position was plotted in a diagram, such as Fig. 8, and it was from an examination of these diagrams that the theory already given was developed.

Having established beyond all doubt the existence of the phenomenon of positional difference, the next step was to compensate for it by using tools of different diameters in the different positions, and in this connection two systems of compensation were investigated. The first system maintained equal clearances of 0·002in. between punch and die in all positions, and consequently required that punches and dies each of four different sizes should be held in stock. The second system maintained equal dies in all positions and effected the required compensation by the employment of different clearances varying from 0·002in. to 0·010in. This had the effect of reducing the number of different kinds of tool to be kept in

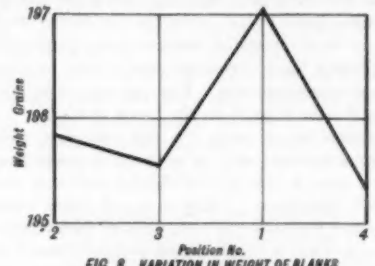


FIG. 8. VARIATION IN WEIGHT OF BLANKS DUE TO POSITIONAL DIFFERENCE
"The Engineer"

stock from eight to five with the added advantage, in the case of combined cutting and cupping dies, that all dies could more easily be made of the same contour.

Properties of Blanks.

Having described some of the difficulties which have been encountered in the manufacture of blanks and the artifices which have been devised to overcome them, a few words will be devoted to the general properties of blanks.

A blank differs in shape from a cylinder in the following respects. The upper face—that is, the face in contact with the punch—consists of a flat annulus with a concave portion within it. The lower face is convex all over. The thickness at the centre is greater and at the edge less than that of the strip. The axis of the blank is not usually perpendicular to the plane of the flat portion of the upper face. A blank is shown in Fig. 9. What may be termed the symmetrical discrepancies, namely, the dishing, thickening at the centre and thinning at the edge, diminish as the hardness of the strip increases, while the unsymmetrical discrepancy—that is, the skew—increases with increasing hardness of strip.

The above refers to blanks cut with small clearance—such as 0·0005in.—between punch and die. Under these conditions the edge of the blank shows a planished surface throughout. If the clearance is larger than about 0·005in. the edge of the blank shows a clean shear fractured surface of conical shape extending for the upper portion of the thickness and a

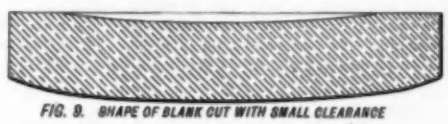


FIG. 9. SHAPE OF BLANK CUT WITH SMALL CLEARANCE

FIG. 10. SHAPE OF BLANK CUT WITH LARGE CLEARANCE

FIG. 11. SHAPE OF BLANK CUT WITH EXCESSIVE CLEARANCE
"The Engineer"

planished cylindrical surface for the lower portion—see Fig. 10. The limiting angle of the cone is about 35 deg., and if the clearance is increased beyond the amount which gives the cone this angle the blank is sheared from the strip without touching the die and the strip is left with a lip turned over into the mouth of the die—see Fig. 11.

If blanks are made as a separate operation it is necessary for them to be reasonably flat so that they may be fed indiscrimately into the cupping machine. This condition is secured if the hardness of the strip is at least 110 Brinell (1000 K, 10 mm.). Any increase in hardness beyond this figure does not effect much reduction in the dishing, but has the disadvantage of increasing the skew. With regard to clearance between punch and die, it may be said that large clearances are undesirable on account of the conical edge, but no advantage is to be gained by reducing the clearance to less than 0·002in., and clearances up to 0·008in. do not seriously mar the appearance of the blanks.

If the blanks are to be cupped immediately by a cupping punch working through a hole in the blanking punch and a combination cutting and cupping die, the strip must, of course, be soft; that is, less than 80 Brinell (1000 K, 10 mm.) and clearances are less important. In fact, clearances up to 0·015in. can be used, but it has not been found necessary to exceed 0·010in.

(To be continued.)

Effect of Metallic Coating upon Fatigue.*

By R. H. D. BARKLIE, M.Sc., and H. J. DAVIES, B.Sc.

MOST of the parts used in engineering are of necessity somewhat irregular in form. Such irregularities or changes of section cause concentration of stress, which has a serious effect on the resistance of the parts to repeated stress, although it has little effect in the case of a once applied load, except in brittle materials.

Statical tensile tests on screwed bars, probably the most common form of discontinuity, have been made by many experimenters. The results show no loss of strength attributable to the screw thread.

Repetition stress tests, on the contrary, show a very serious loss not only on account of screw threads, but even when a fillet of insufficient radius is used to blend two diameters. Using reversed direct stresses, Stanton and Bairstow[1] in 1906 obtained very interesting information on both these points. Since then, owing largely to the development of aircraft, many investigators have studied the subject. Probably the most complete paper from the practical point of view was the one published by Thomas.[2] In that paper Thomas compares the actual stresses realised in practice with the concentrations which are theoretically predicted for elastic material. He concludes that while the actual concentrations in a mild steel are less than the theory would suggest, yet they may still be of very serious consequence. This view is now commonly accepted. Some new experimental results from hardened and tempered steel of 0·86 per cent. carbon are given towards the end of this paper.

That surface defects or conditions, which may not be observable, have a very serious effect on the range of repetition stress has been shown by Lea and Heywood[3] and by Lea and Batey.[4] McAdam[5] and others have also shown that scarcely perceptible corrosion has a most serious effect upon the range of repetition stress.

While the work was being done in the same field at the University of Sheffield, certain nickel-plated mild steel pieces were handed to us by Professor Lea to be tested by repeated stress. These pieces gave a remarkably low fatigue range, and it seemed to us that under certain conditions electro deposits may behave in a manner which is closely akin to that of an abrupt change of section. It was suggested by one of us in 1927[11] that the low fatigue range might be a consequence of initial stress in the nickel layer.

There is a growing tendency to make use of electro-deposition to build up worn parts and to provide a wear and corrosion-resisting surface. The process is in many cases far cheaper than replacement. Nickel

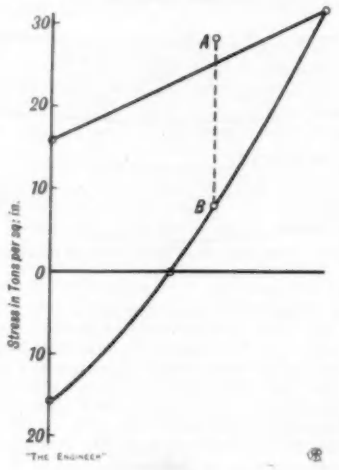


FIG. 1

is commonly used on steel parts on account of its similarity in mechanical properties and on account of its resistance to corrosion. Examples of such applications have been mentioned by Ollard, McLare[6] and Faris[7].

It is stated—see Ollard[8], Macnaughton[9] and Macnaughton and Hothersoll[10]—that nickel deposits may have a Brinell hardness number between 300 and 350 if desired. The value of this degree of hardness, together with the well-known resistance of nickel to corrosion, is obvious, and there is evidently a considerable field for the process. It is therefore especially desirable that its application should not be hindered by failures. For that reason it is well that the risk associated with careless use should be fully appreciated. We wish to state quite emphatically that, although under certain conditions an electro deposit may lead to a loss of strength, yet such loss is not inherent in the process. It may, in fact, be entirely avoided by modified conditions of plating.

Mills in 1877[12] showed that electro-deposited metals are frequently in a condition of stress. In the case of nickel, iron and cobalt this stress is tensile, whilst in cadmium and zinc it is compressive. Quantitative determinations of the stress in nickel were made by Stoney in 1909[13], the metal being deposited on one side of a steel rule and the stress calculated from the bending observed. In recent years many experiments of this kind have been made by Kohlschutter.[14]

The action of an initially stressed outer layer on a piece subjected to alternating stress may be regarded as follows. If we assume, for the moment, that Stoney's value of about 18 tons per square inch exists in a deposit of nickel on a steel rod, it is clear that in a repeated bending test the nickel layer would be subject to a very considerable mean stress upon which would be superimposed the tensile and compressive stresses due to bending. To obtain some idea of the result reference may be made to Fig. 1, which shows that rolled nickel, tested in direct tension and compression in the Haigh machine, has a safe range in tension from 0 to 22½ tons per square inch and for equal tension and compression ±15½ tons per square inch. For intermediate values of the mean stress the safe ranges would be roughly as shown. Now, if we take the bending stress in the nickel to be ±10 tons per square inch, which was approximately the fatigue limit for the plated pieces which had been tested, and add the initial stress of 18 tons per square inch, we get a variation of stress in the nickel A B from 8 to 28 tons per square inch, which is well outside the limits of the diagram. If this be correct, the nickel should crack quite early in a fatigue test.

After the formation of cracks in the nickel the piece might be expected to fail as a nicked or grooved piece, the failure being due to stress concentration at the root of the groove.

To test the validity of the above reasoning the following work was done :—

(i.) Nickel and other metals were deposited under reproducible conditions so that various intensities of initial stress existed.

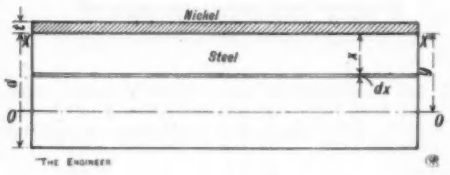


FIG. 2

(ii.) Measurements of initial stress were made on deposits laid down under the conditions of part (i.).

(iii.) The formation of cracks in a stressed nickel deposit was observed during a Wöhler test.

(iv.) Repeated bending tests were made on specimens prepared as in part (i.).

(v.) Mild steel pieces made with sharp nicks of various depths were tested in repeated bending for comparison with the plated specimens.

(vi.) The hardness of nickel deposits made under various conditions was observed.

(vii.) Experiments were carried out using thin intermediate lead films between stressed nickel deposits and steel.

(i.) CONDITIONS OF ELECTRO-DEPOSITIONS.

It is known that the hardness and internal stress of an electrolytic deposit may be varied within wide limits by varying the conditions of deposition. The factors which are of importance in this respect are :—

(*a*) The composition of the plating solution.

(*b*) The current density and the form of current used, as by superposing alternating on direct current.

(*c*) The temperature.

(*d*) The degree of agitation of the solution.

In the following experiments, changes in the composition of the solution were guarded against by the use of a comparatively large volume of liquid, at least 20 litres when the area to be plated was 50 square centimetres. The current density was accurately controlled and the temperature was kept constant by a thermostat. The nickel solution used was one which has a very small tendency to change in acidity,[15] as it is known that the properties of nickel deposits vary very considerably with the acidity. The value chosen for this was *p* H 5·6±0·1.[16] Further experiments in this laboratory have shown that slightly better results from this solution would be obtained by working at *p* H 4. The compositions of the solutions used are given in Table I. The copper solution was a simple acid bath, the lead solution was selected as being capable of giving deposits directly on steel,[12] the zinc solution was that which was determined to be most efficient by unpublished work by Dr. Cocks, carried out at the Royal Aircraft Factory at Farnborough for the Electro-deposition Committee.

In order to obtain nickel deposits as free as possible from stress the temperature of the solution was raised to 50 deg. Cent. and alternating current was superposed on the direct current used for deposition. The fact that an increase of temperature lowers the internal stress in electrolytically deposited nickel was observed by Stoney[13] and by Macnaughton and Hothersall.[10] The effect of alternating current in reducing internal stress in nickel has been described by Staeger[18] and by Kohlschütter and Schodl.[19] By combining these two conditions it is possible to obtain a deposit almost free from stress. When the two kinds of current are superposed in such a way that nickel deposited during the cathodic pulse is partly redissolved during the anodic pulse it is found that the deposition potential is periodically almost destroyed by the anodic pulse and that during the cathodic pulse the time is not sufficient for it to increase to any large value. It has been found by one of the writers (R.H.D.B.) that the stress in electrolytic nickel deposits increases in a linear fashion with the deposition potential. Thus the method of lowering the internal stress in electro-deposited nickel depends upon the combined influence of increase of temperature and of superposed A C in reducing the amount by which the potential at the nickel electrode is displaced from its equilibrium value. This displacement is a measure of the energy available at the nickel electrode, some of which is stored by the production of a stressed deposit.

The method of obtaining the combined current was by passing the direct current used for the deposition through the low-voltage windings of a transformer. To the high-voltage windings, alternating current of 50 cycles at 200 volts is applied. When the direct-current voltage is 4 the alternating current obtained may vary between 6 and 10 volts.

TABLE I.

Deposit.	Solution.	Current density.	Temperature, deg. Cent.	Cathode.	Internal stress.
Stressed nickel ..	$NiSO_4 7H_2O$ 250 gr./litre .. H_2BO_3 30 „ .. NaF 8 „ .. KCl 3 „ ..	10 amps./sq. ft. (pH 5·7)	20	In motion	11·7 tons/sq. in. (tension)
Copper	$CuSo_4, 5H_2O$ 200 gr./litre .. H_2SO_4 60 „ ..	30 amps./sq. ft.	35	In motion	Practically free from internal stress
Zinc	$ZnSO_4$ 143 gr./litre .. Na (OOC.CH_3) ·25 N .. Gum Arabic 1 gr./litre ..	10 amps./sq. ft. (pH 4·3)	18	Still	−1·8 tons/sq. in. (compression)
Lead	Basic lead : Carbonate 150 gr./litre .. 50% H.F acid 240 gr./litre H_2BO_3 105 „ Glue 0·2 „	10 amps./sq. ft.	18	In motion	Practically zero

TABLE II.—*Practical Results, Using Superposed Alternating Current.*

Nickel having reduced internal stress ; solution as described ; temperature 50 deg. Cent. ; direct current 4 volts ; alternating current 6 volts.

	1.		2.
D.C. ..	10 amps./sq. ft.	D.C. ..	10 amps./sq. ft.
A.C.+D.C.	22 amps./sq. ft.	A.C.+D.C.	35·7 amps./sq. ft.
Stress ..	3·7 tons/sq. in.	Stress ..	2·2 tons/sq. in.

The combined current recorded is that shown by a hot wire ammeter. The higher reading was obtained using direct current 4 volts, alternating current 10 volts.

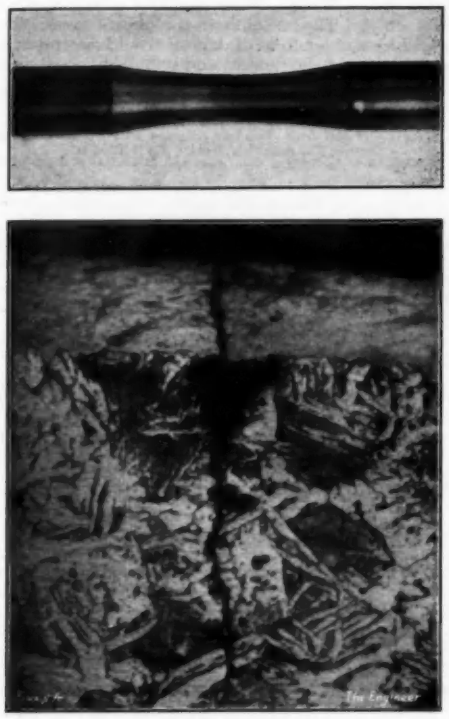
A series of experiments has been carried out to determine the range of conditions within which it is possible to superpose A.C. when electro-depositing nickel from a solution whose composition is similar to that described above. Within the range of conditions producing useful deposits the weight of nickel deposited is that calculated from the direct-current component of the current. During the cathodic pulses the current density is from three to five times that given by the direct current, although the cathodic potential corresponding to this high current density is not developed. The range of conditions of temperature and current density giving useful deposits is more limited when compound current is used than when direct current is used. It is an advantage to offset the effect of high current density during the cathodic pulses by increasing the temperature of the solution.

The hardness of electro-deposited nickel is only slightly diminished when the temperature of the

* Selected for publication in the "Proceedings" of the Institution of Mechanical Engineers.

solution is raised and when alternating current is superposed.

It was important that the results should not be complicated by hydrogen brittleness produced during the preparation of the test pieces for electro-deposition. The specimens were prepared by boiling in caustic alkali, scrubbing with Calais sand wet with alkali, followed by anodic treatment in 10 per cent. sulphuric acid under such a current density that an oxygen film was formed. This process has been described by Ollard. They were then rinsed in running water and placed immediately in the vat. This applied to the electro-deposition of nickel, lead and zinc. For the electro-deposition of copper the test



FIGS. 3 AND 4

pieces were prepared in the manner described and then received a preliminary deposit of copper from a cyanide copper vat.

(ii.) Determination of Stress in Electro-deposited Metals.

The method by which the values given in Table I. were obtained consists in depositing the metal on one side only of a steel strip and measuring the bending of the strip. Spring steel is used, the cross section of which is 0·2306in. by 0·0103in., the length of the plated portion being 3·6in. and the plated area 0·807 square inch. The lower end of the strip is tapered to a point. The overall length is about 5in., the upper end being soldered to a block to which is, in turn, attached a rigid steel pointer, parallel with the strip, which serves as a line of reference.

Determination of Stress.

The complete cathode system is anodically cleaned in dilute sulphuric acid and washed, after which it is lightly plated with gold. The parts which are not to receive a deposit during the test are painted with a solution of celluloid in amyl acetate and acetone. A definite thickness of nickel or other metal is then deposited and the degree of bending measured, after which the deposit is dissolved in an appropriate acid, leaving the device ready for another determination.

Two methods of measurement may be used :—

(1) The cathode strip is plated and set up in an optical projection apparatus, so that the distance between the tip of the plated strip and that of the pointer can be measured, the points being downwards. A beaker containing acid is then brought up to dissolve the deposit, and the change of position of the point is determined. The projection apparatus used gives a magnification of 50.

(2) The plating is conducted in a glass tank with parallel walls at a definite current density and under conditions for which the current efficiency has been determined. The increase with time of the distance between the two points is measured by means of a microscope with an eyepiece micrometer, eighty-one scale divisions corresponding with $^1/_{10}$in. and experiments being usually made with a maximum movement of thirty scale divisions. This method is more convenient, but rather less accurate than (1), the error being perhaps due to an unequal distribution of the deposit over the cathode.

Calculation of Stress.

Since the tendency to bend is the same for each element of the length of the strip, the strip is assumed to bend into an arc of a circle. The length being l and the radius of the circle into which it is bent R, then $R=(l^2-\Delta^2)/2\Delta$, where Δ=deflection. Since l is about 80in. and Δ about 0·1in., $R=l^2/2\Delta$, very nearly.

There is a tensile stress S in the layer of electro-deposited metal, so that the stresses in the beam are distributed as shown in Fig. 2; p is the value in pounds per square inch of the compressive stress in the steel at $x\,x'$.

Taking moments about $x\,x'$,

$$\int_0^d \frac{p}{y}(y-x)\cdot x\cdot d\,x - S\,t\,\frac{t}{2}=0 \quad . \quad . \quad (1)$$

Resolving horizontally,

$$\frac{p}{2}\,y-\frac{p}{2}\,\frac{d-y}{y}\,(d-y)=S\,t \quad . \quad . \quad . \quad (2)$$

d and t are measured, and S has to be determined; y is eliminated from the two equations (1) and (2) and no assumption is made as to the position of the neutral axis.

Stoney[13] measured the tension in electro-deposited nickel films by the bending of a steel scale and assumed the position of the neutral axis to be such that $y=2/3\,d$, very nearly.

Solving the equations (1) and (2) for S,

$$S=\frac{E\,d^2}{6\,R\,t\,(1-t/d)} \quad . \quad . \quad . \quad . \quad (3)$$

t/d may be neglected to give

$$S=\frac{E\,d^2}{6\,R\,t} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

which is identical with Stoney's result.

Putting in the value for R,

$$S=\left(\frac{E\,d^2}{3\,l^2}\right)\cdot\frac{\Delta}{t} \quad . \quad . \quad . \quad . \quad (5)$$

which is used to find the stress.

To make use of the foregoing conclusions it is necessary to know the value of E for the steel strip. This was determined in the ordinary way by a simple bending test, the strip being treated as a cantilever. After an interval of several months the original strip was tested in order to check the value of E. The measurements give the value as from 16,000,000 lb. to 17,700,000 lb. per square inch. The thin film of gold which had been deposited in order to protect the steel during the stress experiments was still present. On testing the same strip in direct tension with an extensometer it gave a value for E of 29,700,000 lb. per square inch, the ordinary figure to be expected from steel. As it seemed possible that the repeated electro-chemical treatment might have injured the surface layer of the metal, which is likely to have a greater effect on bending than on tensile tests, the surface was removed from each side to a depth of about 0·001in. by very gentle lapping between two steel plates. A bending test then gave a value of 29,000,000 lb. per square inch for E. It therefore appears that repeated electro-chemical treatment had damaged the surface layer of the steel in such a way as to have a marked effect on its behaviour on bending. Another strip tested before and immediately after gold plating and boiling showed a reduction of the apparent value of E by bending from 29,000,000 lb. to 28,000,000 lb. per square inch.

The method of cleaning adopted consisted in treating the steel as anode (passive) in 10 per cent. sulphuric acid.

During the measurements of stress the value of the apparent E for the strip was constantly observed. There was a gradual, but not serious, fall in its value, the last determination being 27,100,000 lb. per square inch.

(iii.) Formation of Cracks in an Initially Stressed Nickel Deposit During a Wohler Test.

The actual development of cracks in a stressed nickel deposit on a steel test piece was observed during the progress of a Wöhler test. The steel was prepared

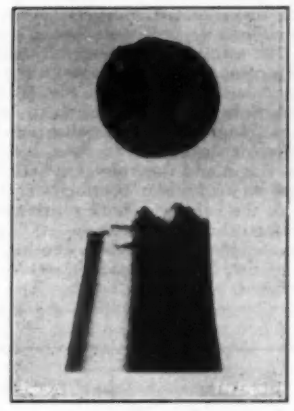


FIG. 7

by anodic treatment in 10 per cent. sulphuric acid. The solution used was the 65-litre vat of nickel sulphate, buffered by boric acid and sodium fluoride. The temperature was 25 deg. Cent., with a moving cathode, the current density 15 ma/cm.^{2}, and the time of deposition ninety minutes. This gave a stressed deposit approximately 0·001in. thick. The plated specimen was then coated with a layer of ferroxyl reagent composed of potassium ferricyanide acidified with hydrochloric acid and dissolved in gelatine solution. This reagent is not affected by contact with nickel, but is turned blue by contact with iron or steel. After thirty hours no blue spots had appeared on the specimen, which was then placed in a Wöhler machine and run under such a load that it might be expected to break after about ten hours. The test was interrupted at intervals of about fifteen minutes for an examination of the test piece, and after each examination the specimen was wiped clean and re-coated with the ferroxyl reagent. After about one hour fine transverse blue lines appeared, and as the test proceeded these lines joined up and widened. The photograph Fig. 3 shows such a test piece after

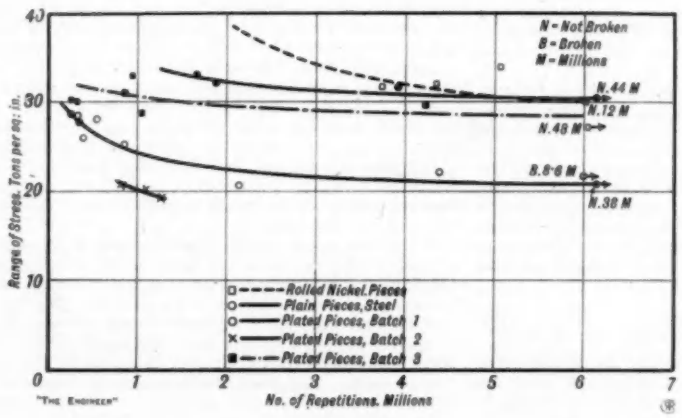


FIG. 5

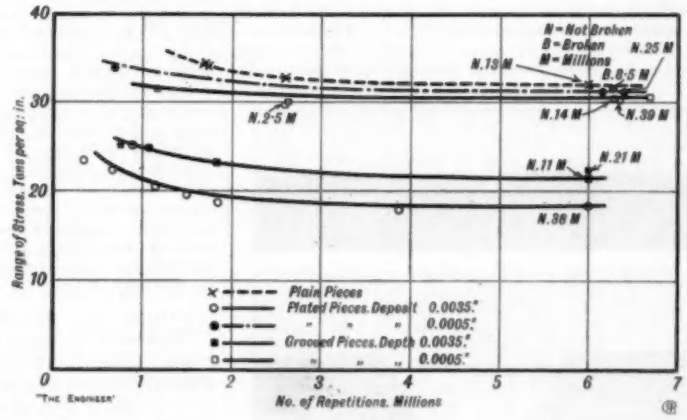


FIG. 6

having run for six hours, that is, after about 500,000 revolutions under a stress of 19·75 tons per square inch. A longitudinal section through the specimen at right angles to the cracks was prepared by taking very light cuts on a surface grinder. After polishing and etching many fine cracks were seen extending through the whole thickness of the nickel layer, and ending abruptly at the surface of the steel—see Fig. 4.

(iv.) Repeated Bending Tests on Electro-plated Specimens.

This work was done on two machines placed at our disposal by Professor Lea. One of them of the

Wöhler or rotating cantilever type is described by Lea in *Engineering*, February, 1923.[20]

The other is of the rotating beam pattern and is described by Lea and Bugden in *Engineering*, August, 1926.[21]

The steels used as the basis metal in these tests were of two kinds; one of 0·09 per cent. carbon was normalised; the other, of 0·14 per cent. carbon, was oil quenched from 890 deg. Cent. Tensile test results are given in Table III. below.

TABLE III.—*Tensile Tests, Mild Steels.*

Material and treatment.	Maximum stress, tons/sq. in.	Reduction of area, per cent.	Elongation, per cent. in 2in.
0·09 per cent. C. steel, normalised	28·4	62·0	42·0
0·14 per cent. C. steel, oil quenched	34·7	73·0	25·0

As was expected, a deposit of nickel made no appreciable difference to the strength of the steel in simple tension.

But when nickel-plated specimens were tested in repeated bending a very distinct loss of strength was observed. The results for commercially plated pieces are shown for comparison with those for the same kind of steel, not plated, in the diagram Fig. 5. The loss of fatigue strength is about 30 per cent. As the deposit was somewhat rough, some pieces were polished before testing, although the roughness was in the form of longitudinal ridges and was therefore unlikely to be a source of serious weakness in bending. This proved to be true, since the values for both rough and polished pieces all fell on the same curve.

To continue the experiments another batch of pieces was plated, but these pieces gave results quite inconsistent with the earlier batch. The points for a deposit which has a low initial stress—see curve for batch 3. This was prepared at the University as described in parts (i.) and (ii.). The safe fatigue range is increased from ±10·2 tons per square inch to ±14·2 tons per square inch, which is very near to the value for unplated steel, *i.e.*, ±15·2 tons per square inch.

Certain pieces in these early tests gave results which

FIG. 8

were inconsistent with the others. On seeking the explanation of this irregularity, it was found that the thickness of the deposit was sensibly different in the cases concerned. This led to two further series of tests, in which the stressed deposit prepared in the University was made definitely of two thicknesses, one of 3½ and one of ½ a thousandth of an inch. The ½ thousandth deposit and the groove of equal depth the difference is the other way. No really satisfactory explanation of this reversal has yet been found. But it is possible that the tensile load on the skin of the steel core due to a thick layer of nickel may be great enough to apply a considerable mean stress to the steel and so to reduce its safe range. If this occurred even to a very limited depth, the extension of the crack into the steel would be rapid. A very thin layer of nickel, on the other hand, would impose very little stress on the steel and there would be no appreciable reduction of the safe range. That is to say, if the total pull exerted by the nickel deposit be great enough to impose a considerable mean stress on the steel at the root of the crack we might expect a greater reduction of the safe range than could be attributed to a crack only. The extent of the mean stress thus applied by a given kind of deposit would depend upon the thickness of the deposit and upon the distribution of the stress across the steel.

(vi.) THE HARDNESS OF NICKEL DEPOSITS.

TABLE IV.—*Nickel from Sulphate Solution with Boric Acid and Sodium Fluoride Additions. No Agitation.*

	Time of plating.	Increase in thickness centre of plate.	Brinell hardness by Vickers diamond (10 kg. load).	
			Edge.	Centre.
Stressed deposit	14 hours	0·004in.	317,287	258,240
Deposit free from stress ..	17 hours	0·0037in.	327,310	287,250

The test pieces were in the form of flat plates. Hardness of uncoated steel plate 184.

(vii.) THE EFFECT OF LEAD FILMS BETWEEN STRESSED NICKEL DEPOSITS AND THE STEEL CORE.

A layer of lead below nickel is able effectively to

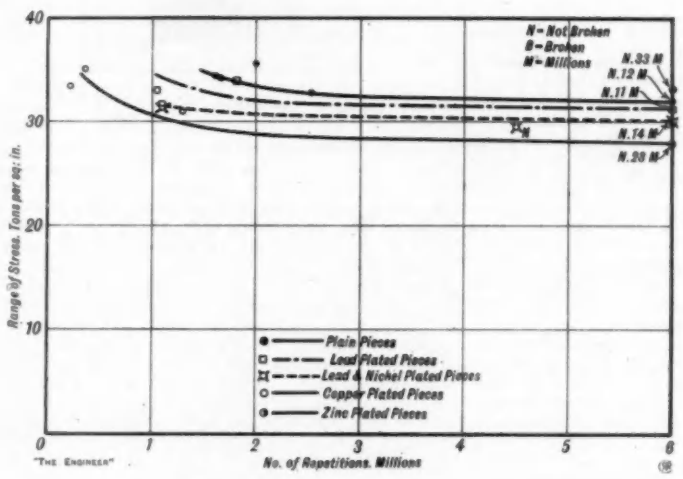


FIG. 9

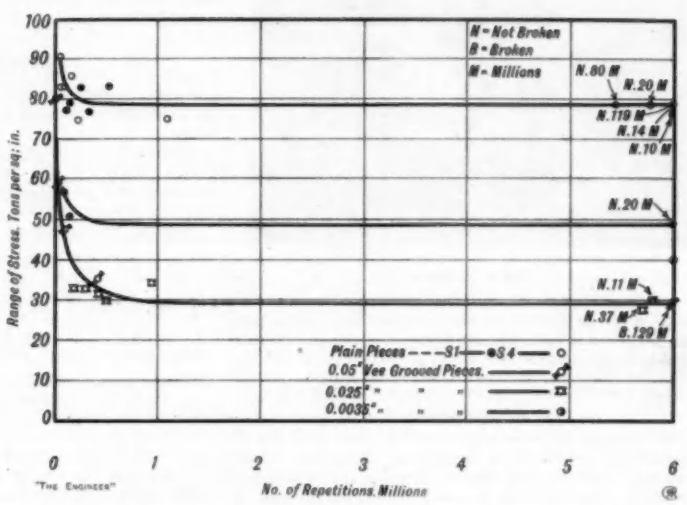
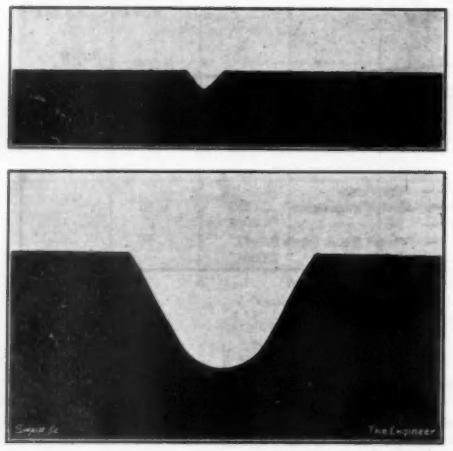


FIG. 10

both sets are shown in Fig. 5 and the second set definitely falls below the first. The first pieces showed a normal fatigue fracture very similar to that of the unplated steel. By comparison the fractures of the pieces of the second set are very irregular and indicate an abnormal brittleness—see Fig. 7. Probably this was due to the employment of an unsuitable cleaning process in preparation for plating. One piece from



FIGS. 11 AND 12

the later batch was turned clear of the plating and then tested. The test showed complete restoration of strength and the form of the fracture was quite regular. This is consistent with the occlusion of hydrogen during pickling, since the effect is only temporary unless the hydrogen is retained by an impervious coating on the steel.

In the same diagram, Fig. 5, is shown the effect of results shown in Fig. 6 indicate clearly that the thickness of the nickel is an important factor. In all cases where nickel has been used the stress has been calculated on the full diameter outside the nickel, except in the case of nickel over an intermediate lead film. For the intermediate lead films and all metals except nickel the stress has been calculated on the area of the steel core only.

Fig. 9 gives the results of repeated bending tests on deposits of lead, copper and zinc. Lead appears to cause a slight loss of strength. Copper, although it is deposited without stress, causes a definite loss. Possibly the relative weakness of copper leads to the early formation of cracks, with the consequent stress concentration at the root. Zinc appears to raise the safe fatigue range of the plated specimen, but further tests are required to confirm this. As was mentioned in the early part of the paper, zinc is deposited with compressive stress.

(v.) REPEATED BENDING TESTS ON MILD STEEL PIECES WITH SHARP CIRCUMFERENTIAL NICKS.

The variation of the safe range associated with different thicknesses of deposit suggested that the effect might be analogous to that of sharp vee nicks of similar depths. Therefore two series of the 0·14 per cent. C steel specimens were made with circumferential grooves of the cross section shown in Fig. 11. This figure is reproduced from a photograph of the groove taken by means of a gauge projection lantern. The actual depth of the groove shown was 0·0035in. and it was enlarged fifty diameters in projection. Fatigue tests on these grooved pieces were made and the results are shown in Fig. 6 for comparison with plated pieces of corresponding dimensions. The 3½ thousandths inch nickel deposit reduces the fatigue range of the 0·14 per cent. carbon steel from ±16 to ±9 tons per square inch. A sharp vee nick of the same depth only reduces the range to ±11 tons per square inch. This difference is probably due to the more acute form of the crack in the nickel, together with the tension in the nickel acting on the steel adjacent. It will be noticed that in the case of the insulate the steel from the effect of cracks in an outermost layer of nickel. If the lead be relatively thick it splits and permits the nickel to shell off. Thin layers of lead avoid this fault, however, and the steel develops almost its full strength, as will be seen by reference to Fig. 9. Confirmation of this was obtained directly by running a test piece with an intermediate lead film at a stress of ±9¾ tons per square inch calculated on the full diameter over the nickel. This was sufficient to cause cracks to form in the highly stressed nickel. The load on the piece was then increased to raise the stress in the steel to ±15¾ tons per square inch. At this load the piece failed to break in five million repetitions, showing that the crack was not able to pass through the lead film and into the steel.

While the work already described was in progress, several tests were made to determine the effect of the depth of the groove in a repetition test piece. These tests were made on steel of 0·84 per cent. (Mark S1) and 0·86 per cent. carbon (Mark S4) oil quenched and tempered to give a Brinell hardness number of about 360. The tensile strength was then about 80 tons per square inch. Repeated bending tests on these steels without grooves and with grooves of various depths were made, with the results shown in Fig. 10. The grooves were all made with a tool of the same form, which was fed in to the required depth. For convenience of reproduction a tool of the form of a sixteen thread per inch Whitworth screw was used. A groove of 0·05in. deep is shown in Fig. 12 and a broken piece in Fig. 8.

It will be noticed that there is little difference between the points obtained for grooves of 0·025in. and 0·050in. deep. But the 0·0035in. groove has far less effect on the resistance to fatigue than either of the others. It appears that between 0·0035in. and 0·050in. depth a limiting value is reached beyond which increase of depth causes no further concentration of stress.

CONCLUSIONS.

1.—Tensile stress in nickel, electro-deposited on a steel test piece, which is subjected to a fatigue test,

acts like a mean stress and seriously reduces the fatigue limit.

2.—The mechanism of this reduction is (*a*) the formation of a crack in the nickel layer under the combined influences of its own tensile stress and of the stress applied in the test; (*b*) the concentration of stress at the base of this crack.

3.—The reduction in the fatigue limit is greater than that produced by a circular nick of depth equal to the thickness of the nickel deposit. The nickel, being in a state of internal stress, will exert an influence tending to widen the crack. Thus the concentration of stress at the base of the crack in nickel is greater than that of the base of a crack in steel.

4.—The difference between the effects of circular nicks and stressed nickel deposits diminishes as the thickness of the deposit and the depth of the nick are decreased. This is in accordance with conclusion 3.

5.—Electro-deposits of nickel having little internal stress have a greatly reduced influence on the fatigue range of steel. The conditions for the electro-deposition of nearly stress-free nickel are described. It is advisable to use such deposits for building up, especially when the thickness exceeds 0·001in.

6.—Electro-deposits of copper free from internal stress reduce the fatigue limit of steel. This is in accordance with the fact that the tensile strength of copper is less than that of mild steel, so that a range of stress without influence on steel would crack copper.

7.—Electro-deposits of zinc having a slight internal stress causing them to expand do not lower the fatigue limit of steel. This is in qualitative agreement with conclusions 1, 2, 3, and 6.

8.—Electro-deposits of lead are without serious influence on the fatigue range of steel. We consider the effect of the low-tensile strength to be offset by the fact that a concentration of stress greater than the low-tensile strength of lead cannot arise at the base of a nick in the lead sheath.

9.—Intermediate lead films between stressed nickel and mild steel have been found to insulate the steel core from effect of stressed nickel deposits. Films as thin as ten-millionths of an inch have been found to have this property. Such films may have considerable value where it is essential to eliminate all risk of failure due to cracking of a deposit.

10.—As the thickness of the intermediate lead film is reduced the apparent adhesion of the nickel deposit is increased. Using very thin lead films, the appearance of the fracture of a Wöhler test piece is similar to that of a test piece in which the nickel is plated directly upon steel.

11.—Certain processes preliminary to electroplating have been found to destroy the mechanical continuity of the surface layers of a steel strip.

12.—Circumferential grooves have a much more serious effect on the safe range of stress in hard steel than similar grooves in mild steel. The concentration of stress even in the hard steel is still well below that for elastic material.

13.—For a groove of given root radius there appears to be a limiting depth, beyond which greater depth has no further influence on the resistance of the steel to repeated stresses.

The authors desire to express their thanks to Professor Lea and Professor Desch for their encouragement and assistance in affording facilities for carrying out the work described in this paper.

During the investigation one of the authors—R. H. D. Barklie—was working under the supervision of Professor C. H. Desch for the Electro-deposition Committee of the Department of Scientific and Industrial Research. It is desired to express the thanks of the authors to the Electro-deposition Committee for permission to publish the results.

REFERENCES.

[1] Stanton and Bairstow, "Proc.," Inst. Mech. Engrs., 1906.
[2] Thomas, *Engineering*, October 12th, 1923.
[3] Lea and Heywood, "Proc.," Inst. Mech. Engrs., April, 1927.
[4] Lea and Batey, "Proc.," Inst. Mech. Engrs., December, 1928.
[5] McAdam, Amer. Soc. for Testing Materials, June, 1929, and earlier papers.
[6] McLaren, "Trans.," Faraday Soc., 1924.
[7] Faris, Diesel Engine Users Assoc., 1929.
[8] Ollard, "Trans.," Faraday Soc., 21, 81, 1925.
[9] Macnaughton, *Journal.*, Iron and Steel Inst., I., 419, 1924.
[10] Macnaughtan and Hothersall, "Trans.," Faraday Soc., 1928, 7, 387.
[11] Barklie, Electroplaters' and Depositors' Technical Soc., London, October, 1927.
[12] Mills, "Proc.," Royal Soc., 26, 504, 1877.
[13] Stoney, "Proc.," Royal Soc., 82a, 172, 1909.
[14] Kohlschütter, *Zeit. Elektrochem.*, 24, 300, 1918.
[15] Lea., "Proc.," Royal Soc., 123a, 1929.
[16] "Trans.," Amer. Electrochem. Soc., 41, 333, 1922.
[17] Blum, "Trans.," Amer. Electrochem. Soc., 36, 243, 1919.
[18] Staeger, Helv. Chim. Acta., 3, 584, 1920.
[19] Kohlschütter and Schodl, Helv. Chim. Acta., 5, 593, 1922, and 5, 490, 1922.
[20] Lea, *Engineering*, February, 1923.
[21] Lea and Budgen, *Engineering*, August, 1926.

JUBILEE DINNER, MATT'W. T. SHAW AND CO., LTD.—A dinner, attended by the directors and staff of the long-established firm of constructional engineers, Matt'w. T. Shaw and Co., Ltd., of Millwall, was held at Anderton's Hotel, on December 5th, to celebrate the occasion of fifty years' continuous service with the company of two of the members of the staff. There were present four retired members of the staff with service averaging fifty-one years. Mr. A. W. Thatcher—who is retiring—was the recipient of a canteen of cutlery, together with a silver salver, whilst Mr. John S. Hierons, the present secretary and director, was presented with a gold cigarette case with match box and a smokers' companion.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE SHISHKOFF HYDRO-THERMAL STORAGE SCHEME.

SIR,—The Shishkoff hydro-thermal tidal power system described in your issues of September 20th and October 3rd last compels comment.

There are vitally important phases which appear to require further thought. The most important appears to be that Mr. Shishkoff inflicts on hydro-electric schemes the inherent inefficiency of the steam cycle, and in doing this he chooses what is probably the least efficient method of doing so, *i.e.*, he supplies variable pressure and probably very wet steam to a turbine.

It is interesting to examine the figures obtained on the experimental plant at Avonmouth.

On test No. 2, held on July 30th, 1930, the steam pressure in the accumulator at the start was 144 lb. per square inch, and after one hour's run was 48 lb. per square inch. It will be seen that the temperature drop was 67 deg. Fah. and heat released was 69·7 B.Th.U. per pound of water. Taking the water content at 24,960 lb., it will be seen that 1,740,000 B.Th.U. were liberated in the one-hour run, during which 30 kWh were generated, giving a consumption of 58,000 B.Th.U. per kWh, equal to a thermal efficiency of about 6 per cent.

I am afraid that, to explain this, it is useless to suggest that the plant is merely experimental. The low efficiency is, of course, due to the law of thermodynamics and the fact that variable pressure wet steam is not the best medium for getting the best out of the imposed limitations.

The same disappointing features are apparent from the more conclusive tests carried out on August 27th.

In this test, No. 2, the gauge pressure at the start was 29 lb. per square inch and at the end of the eight-hour run was 132 lb. per square inch, *i.e.*, the water in the thermal storage system was raised through 84·9 deg. Fah. and received 86·5 B.Th.U. per pound. The heat gained in the accumulator during this period was 1,764,200 B.Th.U., indicating a total water content of 20,400, which is in agreement with the quantities given in connection with the other tests.

Taking the July 30th figures as indicating the efficiency of conversion of this stored heat, we have 6 per cent. of 1,764,200=105,852 B.Th.U. usefully converted, equal to, say, 31 kWh., which puts quite a different complexion on the figures given in connection with the test held on August 27th, 1930.

If for "percentage of turbine output stored" the more rational quantity "percentage of turbine output stored and usefully converted" be substituted, we have 105,852 B.Th.U. for 1,764,200 B.Th.U., and the turbine energy usefully converted by direct generation of electricity and by indirect generating *vid* the accumulator becomes 789,852 B.Th.U. instead of 2,448,200, *i.e.*, 23 per cent. of the total water turbine output instead of 72·4 per cent., which is the figure obtained before considering the conversion of the stored heat into useful energy.

These figures, of course, drastically alter the basis of calculations for tidal power schemes founded on the Avonmouth efficiencies as stated in your issue of October 3rd, 1930. The obvious conclusion is that the method of utilisation of the stored heat is inefficient.

The development of tidal power is, of course, too important to be influenced by preliminary mistakes, but it does seem very unfortunate that the early experiments should have included a heat engine with its essential limitations of efficiency greatly increased by the system of storing and liberating the heat. Very different figures would have been obtained had the heated water been utilised as feed water in modern high-pressure boilers supplying turbines using, say, 10 lb. of steam per kWh developed. Such an arrangement compels the tidal power scheme to be regarded as an adjunct to a steam-driven station, in which case ideas of efficiency must be modified. The relation of its cycle to that of the main power-house affords food for reflection.

It is clear, however, from the Avonmouth figures that the ideal condition for tidal power is that it should be delivered as generated to the grid system.

It will be remembered that the Electricity Supply Act provides for the purchase of electricity generated at sources other than in the recognised stations.

Swansea, December 11th. G. E. HIDER.

[In fairness to Mr. Shishkoff it ought to be said that he is, as was stated in our articles, fully alive to the inefficiency of the heat accumulator-turbine element of his plant, and that even before the tests which we detailed were made he was actively studying the undoubted advantages to be obtained by running the accumulator-turbine element in conjunction with fuel-fired boilers much in the manner suggested by our correspondent.—ED. THE E.]

THE LIVERPOOL AND MANCHESTER RAILWAY.

SIR,—The centenary celebrations of the Liverpool and Manchester Railway have revived interest in the early locomotives. Mr. C. F. Dendy Marshall, who has rewritten the history of the Rainhill trials of 1829 and the opening of the railway in 1830, has been able by his discovery and acquisition of Rastrick's notebook to throw fresh light on the events, but he also comments on certain unaccountable discrepancies in the illustrations and descriptions of the "Rocket" given by others in those early days. Likewise Mr. J. H. G. Warren, in his book on "A Century of Locomotive Building by Robert Stephenson," remarks on these inconsistencies.

Quite by chance I discovered some correspondence which took place in the *English Mechanic* in the years 1884–85, and from which it appears that it was eventually established without a doubt that there were two locomotives bearing the name "Rocket" on the Liverpool and Manchester Railway in 1830, one the engine which took part in the Rainhill trials, and a second built in 1830, which was evidently intended for some other railway but was running its trials on the L. and M. Railway, just as the first "Rocket" had done on the Killingworth Colliery line before being sent to Rainhill. These engines were very similar in appearance, and this led to some confusion in the minds of those not acquainted with the circumstances; hence the differences in the contemporary drawings. But the 1830 "Rocket" was apparently the one which took part in the opening ceremony and fatally injured Mr. Huskisson. For some reason this fact seems to have been lost to sight after a lapse of forty-five years, but at the time the correspondence took place it was only fifty-five years after the event, and it was still possible for the older generation to remember and give first-hand information to confirm this point.

From the correspondence which ensued, it was made clear that the 1829 engine continued to run on the L. and M. Railway until 1837, when on account of the rapid growth of train loads, it was of no further use, and was offered for sale. It was bought for a colliery line between Lambley and Kirkhouse in Cumberland, where it gave satisfaction for some years. After being laid up for a time at Kirkhouse it was eventually sold to the South Kensington Museum in 1862.

The "Rocket" of 1830 was used for working ballast trains during the construction of the L. and M. Railway. It seems to have been rather like the "Northumbrian" in appearance, but had stays to the chimney. Stephenson was evidently dissatisfied with the engine on account of slipping and other troubles, and after the tragedy of the opening day he made up his mind to send it back by sea to Newcastle and rebuild it with coupled wheels, and this was done.

Meanwhile the rapid improvement in design had resulted in the building of Stephenson's "Planet" type later in 1830, which rendered all the "Rocket" type obsolete, at any rate as far as the L. and M. Railway was concerned.

However, after a lapse of two years the 1830 "Rocket" was sold to the Leicester and Swannington Railway for the sum of £560, plus £40 for the cost of alterations, and it was sent by water to the West Bridge Wharf, Leicester, arriving on March 10th, 1832. It was put together at Fosse-lane sidings, and was used for the opening of the line on July 17th, 1832, being driven by Robert Weatherburn, afterwards locomotive foreman at Carnforth. In 1835 the engine was sold for constructional work on the London and Birmingham Railway between Rugby and Kilsby Tunnel. On completion of the railway it was used by Mr. John Cummins, who had contracted for the upkeep of the section of the line between Rugby and Birmingham for a sum of £300 per mile per annum. In 1849 the engine was sold to a South Wales colliery tramway, near Swansea, after which all trace of it was lost.

At some time during its career this engine's name was changed to "Comet." It appeared on the books of the Swannington Company as engine No. 1, and the name "Rocket" was struck through and "Comet" was added below, the alteration being initialled by the manager of the line on July 17th, 1832. The engine had been used for working ballast trains during the construction of the line, and before the opening day received a new coat of paint and apparently a change of name. This, no doubt, deceived the public, for it was regarded as a brand new engine for the occasion.

The dimensions of the engines, as given in the correspondence, are as follows:—

	1829 "Rocket"	1830 "Rocket"	1830 "Rocket" rebuilt as "Comet."
Type	0–2–2	0–2–2	0–4–0
Cylinders	Not mentioned	12in. by 16in.	12in. by 16in.
Boiler—			
Diameter of barrel	Ditto	3ft.	3ft.
Length of barrel	Ditto	6ft. 6in.	6ft. 6in.
No. of tubes	25	97	97
Diameter of tubes	3in.	1¾in.	1¾in.
Heating surface of tubes, sq. feet	117	303	302·9
Fire-box:			
Length	3ft.	2ft.	2ft.
Width	3ft.	3ft.	3ft.
Height above bars	2ft.	3ft.	3ft.
Heating surface, sq. feet	20	25·5	25·46
Grate area, sq. feet	Not mentioned	6·0	6·0
Driving wheels, diameter	Ditto	5ft.	5ft.
Trailing wheels, diameter	Ditto	3ft.	5ft.
Weight in working order with tender	t. c. q. 7 9 0	t. c. q. 8 17 0	t. c. q. 9 9 2

An inspection of these dimensions shows that the "Rocket" of 1830 had a much greater boiler capacity, and therefore the engine of Rainhill fame with its 8in. diameter cylinders would make a poor showing against it and the other engines of 1830 having about twice the tractive effort and heating surface. It is probable that the 1829 engine was kept in the background on the opening day, and the eight engines used for drawing trains would then be of approximately equal power. At any rate, the "Northumbrian," clothed in polished copper plates and driven by George Stephenson himself, headed the pro-

cession, with the "Phœnix" following on the adjacent line. The "Rocket" used on that occasion does not seem to have been given the place of honour its Rainhill reputation deserved, and this again rather points to the existence of a second and less glorious engine of the same name.

December 15th. H. HOLCROFT.

DIVIDING THE CIRCLE.

SIR,—With regard to the letter from "Ixion" in your issue of the 12th inst., I suggest that the problem lends itself readily to mathematical analysis, leading to a very simple method of choosing the right tooth at which to begin correcting the pitches.

Considering the general case of a wheel having n teeth, let the successive pitches (as measured) be $p_1, p_2 \ldots p_n$, which, if p is the mean pitch, are equal to $p+d_1$, $p+d_2, \ldots p+d_n$ respectively.

Then if we choose some tooth, t_x, at which to start, we begin by correcting p_x, which equals $p+d_x$. To do so, we must remove an amount d_x from the face of t_{x+1}, in order to reduce p_x to p, assuming d_x to be positive.

This increases p_{x+1} by an amount d_x, so that

$$p_{x+1}=p+d_{x+1}+d_x.$$

After correcting p_{x+1} we have similarly

$$p_{x+2}=p+d_x+d_{x+1}+d_{x+2},$$

and, in general, if t_r be *any* tooth, after correcting p_{r-1},

$$p_r=p+d_x+d_{x+1}+ \ldots +d_{r-1}+d_r.$$

In order that it should be possible to continue with the

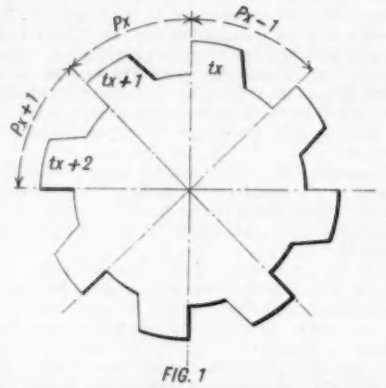


FIG. 1

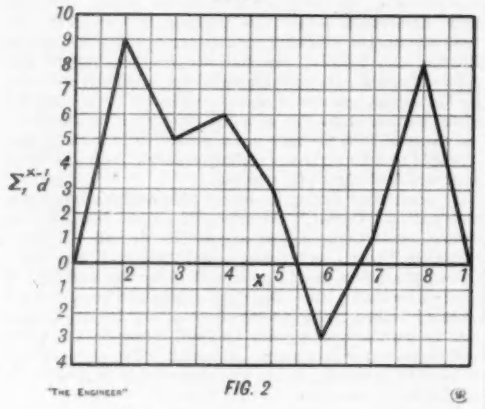


FIG. 2

correction it is necessary and sufficient that p_r is not less than p, for any value of r, *i.e.*, $d_x+d_{x+1}+ \ldots +d_{r-1}+d_r$ is always positive or zero, or $(d_1+d_2+ \ldots +d_r)-(d_1+d_2+ \ldots +d_{x-1})$ is positive or zero for all values of r.

Hence if t_x is the tooth at which correction should start, it is necessary that $(d_1+d_2+ \ldots +d_{x-1})$ is a minimum.

This gives a simple method of finding the correct tooth graphically. Fig. 2 is a graph of $(d_1+d_2+ \ldots +d_{x-1})$, or $\Sigma_1^{x-1} d$, as ordinate and x as abscissa. The lowest point on the graph is immediately apparent, and hence shows the number, x, of the tooth from which correction must start. This graph is actually drawn for the case put forward by your correspondent, and will be seen to agree with his conclusion obtained by trial.

Although at the commencement it was assumed that d_x was positive, similar reasoning would apply if d_x were taken to be negative, in which case, of course, the correction would proceed clockwise instead of anti-clockwise.

Derby, December 15th. J. BARTON.

SIR,—With reference to "Ixion's" letter of your issue of December 12th, on page 647, I would suggest the following method :—

Write down the pitches p_1 p_2, &c., in terms of the correct pitch $\pm$ error and starting at any tooth, say, T_1, write down what requires to be removed till you arrive at a negative figure, then go back to the first tooth and start again by removing this (negative) figure from the first tooth and follow round again. If again a negative figure occurs, add this to the original and start again. The accompanying table illustrates this method applied to the example given by "Ixion." You will notice that the last figure (against P_8) is 3, which agrees with the figure 3 against T_1. I have not had time to work this out mathematically, but in any case I think the above method would be the simplest.

			1st trial. Remove.	2nd trial. Remove.
T_1			0	3
	P_1	251+9		
T_2			9	12 (3+9)
	P_2	251−4		
T_3			5 (9−4)	8 (12−4)
	P_3	251+1		
T_4			6 (5+1)	9 (8+1)
	P_4	251−3		
T_5			3 (6−3)	6 (9−3)
	P_5	251−6		
T_6			−3 (3−6)	0 (6−6)
	P_6	251+4		
T_7				4 (0+4)
	P_7	251+7		
T_8				11 (4+7)
	P_8	251−8		3 (11−8)

In the example given by "Ixion" it may be noticed that if we divide the teeth into two halves and add any four consecutive pitches, the total error is a maximum in either direction when starting with P_8.

Dunstable, December 15th. E. A. G. S.

SIR,—I was much interested in the problem set by "Ixion" in your last issue, and beg to suggest the following method of solution. At the outset it might be mentioned that this is a case where the description takes longer than the actual working, the latter being simple once the underlying idea is grasped.

Taking the specific example selected, the first stage is to subtract—algebraically—the mean pitch (251) from the rough pitches, which were as follows :—

p_1	p_2	p_3	p_4	p_5	p_6	p_7	p_8
260	247	252	248	245	255	258	243

the above −251 give

+9	−4	+1	−3	−6	+4	+7	−8

Set these figures against the corresponding pitches on the diagram :—

The following simple rules will then show at which tooth to start in order to fulfil the conditions :—

Adjacent numbers of like sign may be added together and treated as one, *e.g.*, +4 and +7=+11.

The summation of the numbers starting from the required tooth must always give a positive value.

It is obvious that the zero tooth must have the largest positive numbers immediately preceding it, in this case either +9 or +11.

A quick mental calculation will show that the zero tooth, clockwise, should be tooth 2, and anti-clockwise tooth 6.

In the present example there are two fairly large positive numbers which do not differ much (9 and 11), and it will be seen that the respective starting points "embrace" them both. Where there is one outstanding positive number it will be found that the starting points "embrace" it only.

The solution given by "Ixion" for the clockwise direction is obviously wrong, as the first pitch after tooth 6 in this direction is 245, which is less than the mean, so that the next tooth would require metal added. DALGIAN.

Woking, December 16th.

SIR,—I submit a mathematical solution to your contributor's problem on correcting the tooth pitch of master dividing wheels.

Starting from the first tooth, let the spaces be p_1, p_2 $\ldots$ p_n, measured in any convenient units, and $P=\frac{1}{n}(p_1+p_2+ \ldots +p_n)$. The amounts of metal which would have to be removed to equalise the pitches are :—

$$a_1=P-p_1$$
$$a_2=2P-p_1-p_2,$$
$$\ldots\ldots$$
$$a_{n-1}=(n-1)P-p_1-p_2- \ldots -p_{n-1}$$
$$a_n=nP-p_1-p_2- \ldots -p_n$$
$$=0.$$

Now, if all the a's are not positive, let $a_r=-\alpha_r$ be the numerically greatest negative one. Take

$$a^1_{r+1}=a_{r+1}+\alpha_r,$$
$$a^1_{r+2}=a_{r+2}+\alpha_r,$$
$$a^1_n=a_n+\alpha_r,$$
$$a^1_1=a_1+\alpha_r,$$
$$a^1_{r-1}=a_{r-1}+\alpha_r,$$
$$a^1_r=0.$$

These are the amounts to be removed if we start from the rth tooth, and they are all positive. Moreover, if we start from any other tooth, say, the sth, one at least of the new quantities a^s must be negative. Hence the choice of the starting tooth for each direction of rotation is uniquely determined. Example :—

If the pitches are 5, 6, 8, 7, 6,

$$P=6^2/_5,$$

and the a's are $+1^3/_5$, $1^4/_5$, $^1/_5$, $-^2/_5$, 0. Hence we must start from the fifth tooth, the new values of the a's being a_5^1, a_1^1, a_2^1, a_3^1, $a_4^1=^2/_5$, $1^4/_5$, $2^1/_5$, $^2/_5$, 0.

Nottingham, December 14th. A. I. RYNESS, B.A.

[Replies of a somewhat similar nature have also been received from Professor C. H. Bulleid, Mr. A. A. Clements, Mr. J. F. A. Vellacott, and Mr. W. A. Tuplin. We have forwarded them to our correspondent.—ED. THE E.]

THE INFERIORITY COMPLEX.

SIR,—Sir A. Duckham's reply to my letter to you is very weak. I or your readers have no interest in studying plant orders over the past ten years. We live in the present and the mill will never turn again with the water that has passed. My point was that immense plants of foreign design are being erected in the London area. Does Sir Arthur deny that? I call it a national disadvantage that it is so, and I want to know the reason. Are the foreign plants cheaper or better, or both, or either, or neither?

The coke oven industry seems to be beyond recovery from royalties to foreigners. Need it be?

I thank "Carboniser" for his remarks.

London, December 15th. W. W. S.

Modern Switchgear.

THE ever-increasing size of power stations and generating plant has been accompanied by radical changes in the design of switchgear, which now bears little resemblance to that which was employed in the past. As the amount of power to be controlled increased, the early flat switchboards composed of slate or marble were followed by the cellular type of switchgear introduced by the late Dr. Ferranti. Still greater increases in the generated power introduced new problems, which began to be successfully met in the year 1905, when Mr. H. W. Clothier designed

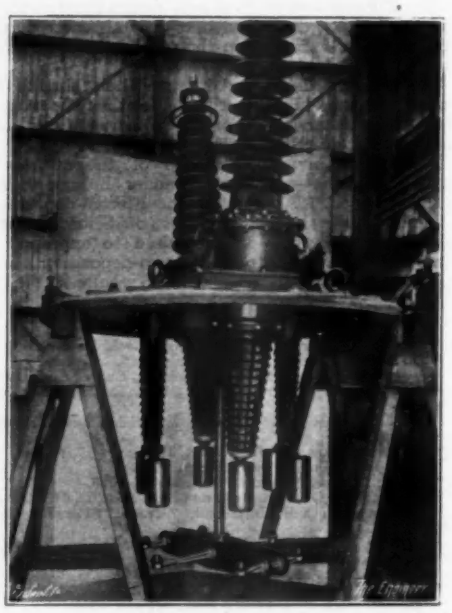


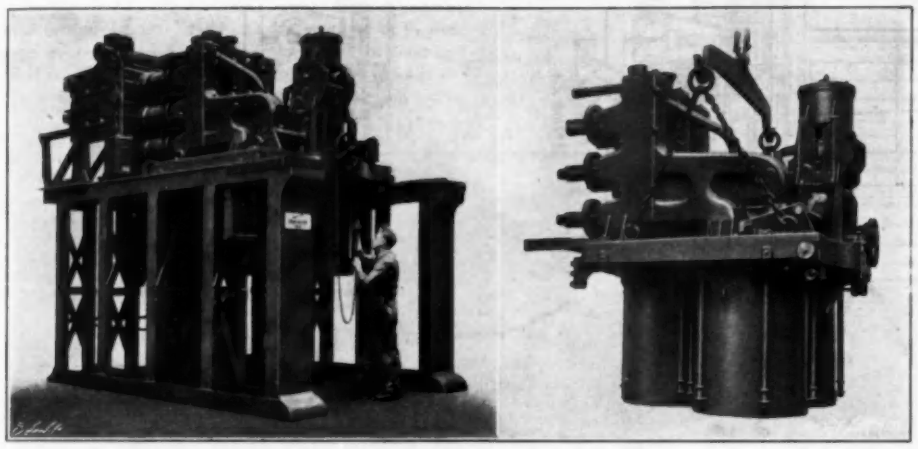
FIG. 1—"GRID" CIRCUIT BREAKER CONTACTS

draw-out metal-clad switchgear. The earliest horizontal draw-out metal-clad circuit breaker was built at Reyrolle's works in 1906, and succeeding years vindicated the correctness of the principle it embodied as a means of securing safe and simple operation. Since the time of its introduction continuous developments of the horizontal type of gear have taken place, and recently the makers have produced a type RM circuit breaker rated at 4000 ampères at 12,000 volts with a breaking capacity of 1,000,000 kVA this being, it is said, the largest horizontal draw-out metal-clad switchgear unit that has been built.

Owing to the large size of the unit which is shown in Fig. 2, the usual racking handle has been replaced by a chain and chain wheel, which make it easy for the attendant to withdraw the circuit breaker from its working position for the purpose of isolation. As the circuit breaker is being withdrawn, locking-off doors close over the orifices

of the bus-bar chambers and thus make it impossible for anyone accidentally to make contact with the live parts. These locking-off doors are to be seen between the spouts of the bus-bar chambers in the illustration.

A special feature of the new Reyrolle type RM switch-



FIGS. 2 AND 3—LARGE METAL-CLAD CIRCUIT BREAKER

gear, which we inspected during a recent visit to the firm's works, is the complete separation of the phases in the circuit breaker portion of the gear. When they leave the bus-bars the phase conductors pass down separate hoods into three separate tanks, which house the circuit breaker

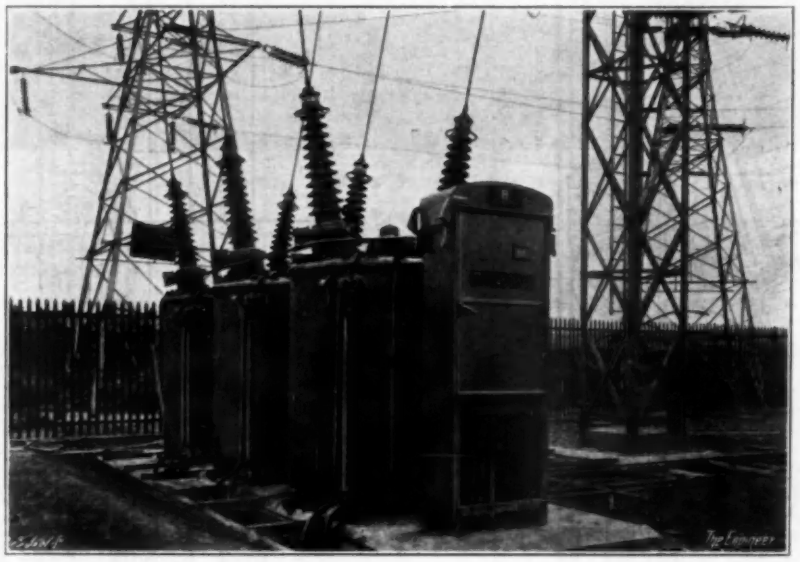


FIG. 4—BANK OF THREE-PHASE "GRID" CIRCUIT BREAKERS

contacts. The tanks are cylindrical and are fitted with dished ends made of boiler plate steel, and, by adopting this method of phase isolation, it is impossible for short circuits to occur between phases, whilst the cylindrical tanks give the strength required to withstand the internal pressure set up when the breaker is called upon to break short circuits. The breaker is operated magnetically by means of a solenoid, and interlocks ensure that everything is in a safe condition before it can be closed, which may be done, if necessary, by hand by means of an ingenious device utilising a hydraulic jack. This appliance can be operated when the circuit breaker is drawn out and isolated, and it is arranged to permit of the contacts being closed slowly and of the closing movement to be interrupted at any time so that the action of the moving contacts can easily be studied. The illustration Fig. 2 shows a duplicate bus-bar circuit breaker arranged for bus-bar selection by means of detachable plugs, but the circuit breaker can also be supplied with selector switches for changing over from one set of bus-bars to the other, the selector switches being oil-immersed and operated by an electric motor. The illustration Fig. 3 shows the circuit breaker portion of the R.M. unit withdrawn from the framework and suspended from a crane.

The switchgear described has been designed by A. Reyrolle and Co., Ltd., for use indoors, where saving in floor space is an important matter, but where switchgear can be installed in the open it is not so necessary to limit the floor space, and for high voltages, such as those adopted on the British "grid," circuit breakers such as those shown in Fig. 4 are employed. This illustration shows a bank of three-phase Reyrolle circuit breakers installed at the Luton sub-station on the South-East England section of the grid, the circuit breakers being rated at 600 ampères at 132 kV and are designed to break 1,500,000 kVA.

The operating mechanism is contained in the box seen at the end of the circuit breakers, and consists of a solenoid which turns a shaft running across the tops of the circuit breakers. Pinions keyed to this shaft co-operate with racks attached to the plunger bars of the circuit breakers, and, when the pinions are turned, the plunger bars are raised or lowered so as to close or open the circuit breaker contacts. The illustration Fig. 1 shows the arrangement of contacts inside the circuit breaker tanks, and it will be perceived that six breaks per phase are obtained. The area of the arc exposed to the cooling effect of the oil is therefore extremely large, and the minimum amount of energy is liberated during the opening of the breaker. A close view of one of the contacts is given in Fig. 5, where the corona shield has been removed in order to show the multiple contact fingers surrounding the central arcing contact.

As will readily be understood, these outdoor circuit breakers are of considerable weight, and actually the three-phase bank shown in Fig. 4 weighs about 30 tons. In the design of outdoor sub-stations the questions of transport, overhauls and repairs must therefore receive careful consideration. Owing to the presence of overhead wires it is generally impossible to provide a crane for moving the circuit breakers, and a bogie running on rails is

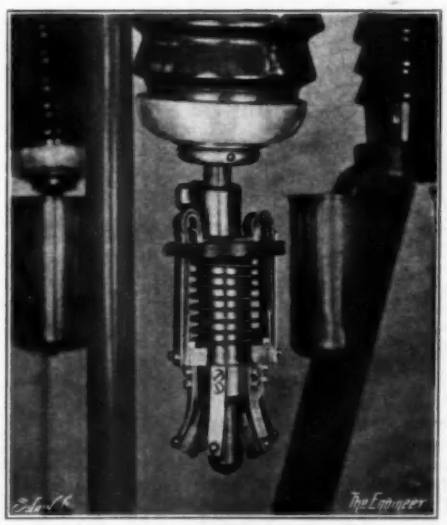


FIG. 5—CONTACT WITH CORONA SHIELD REMOVED

generally employed. It is often inconvenient to raise the circuit breakers by means of jacks, and then to run a bogie under them in order to remove them, and Reyrolles have therefore designed a lifting device to perform the dual function of lifting the breakers and transporting them. The device is divided into two similar portions, which are applied to each side of the tank, and Fig. 6 shows one of these devices in use. Two lugs are hooked on to projections on the circuit breaker tank, and on turning the small handle to be seen just above the wheel the circuit breaker is raised or lowered. The application of the second portion of the device to the other side of the tank provides practically a bogie with four flanged wheels, and the circuit breaker can be moved bodily along rails by means of the main handle, which is connected to the bogie wheels by means of a ratchet mechanism, and by being moved up and down causes the wheels to turn and the bogie to move.

In order to reduce maintenance costs the reconditioning

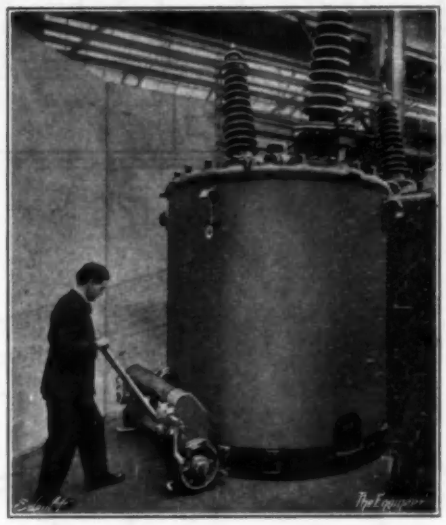


FIG. 6—CIRCUIT BREAKER LIFTING DEVICE.

of oil used in these large circuit breakers is a matter of importance, and centrifugal filters are employed for the purpose. In these equipments filter papers are used, and Fig. 7 shows an oven designed by A. Reyrolle and Co. for drying these papers. The oven consists of two sheet metal cases, one inside the other and having the space between them and that in the door of the oven filled with an efficient heat-insulating material. In the base of the oven there are three heating elements, which are connected to a three-heat plug and socket, which enable the heat of the oven to be controlled, whilst a standard porcelain fuse is connected in the heating circuit to protect the elements against overload. The base of the oven consists of a perforated sheet metal plate, which protects the articles to be

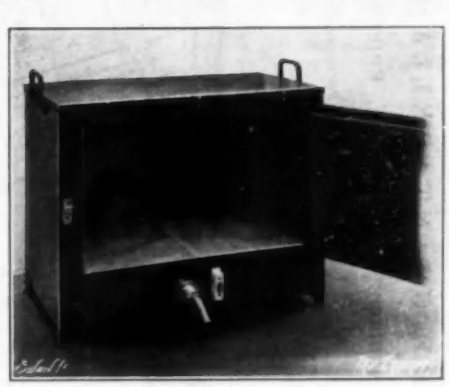


FIG. 7—FILTER PAPER DRYING OVEN

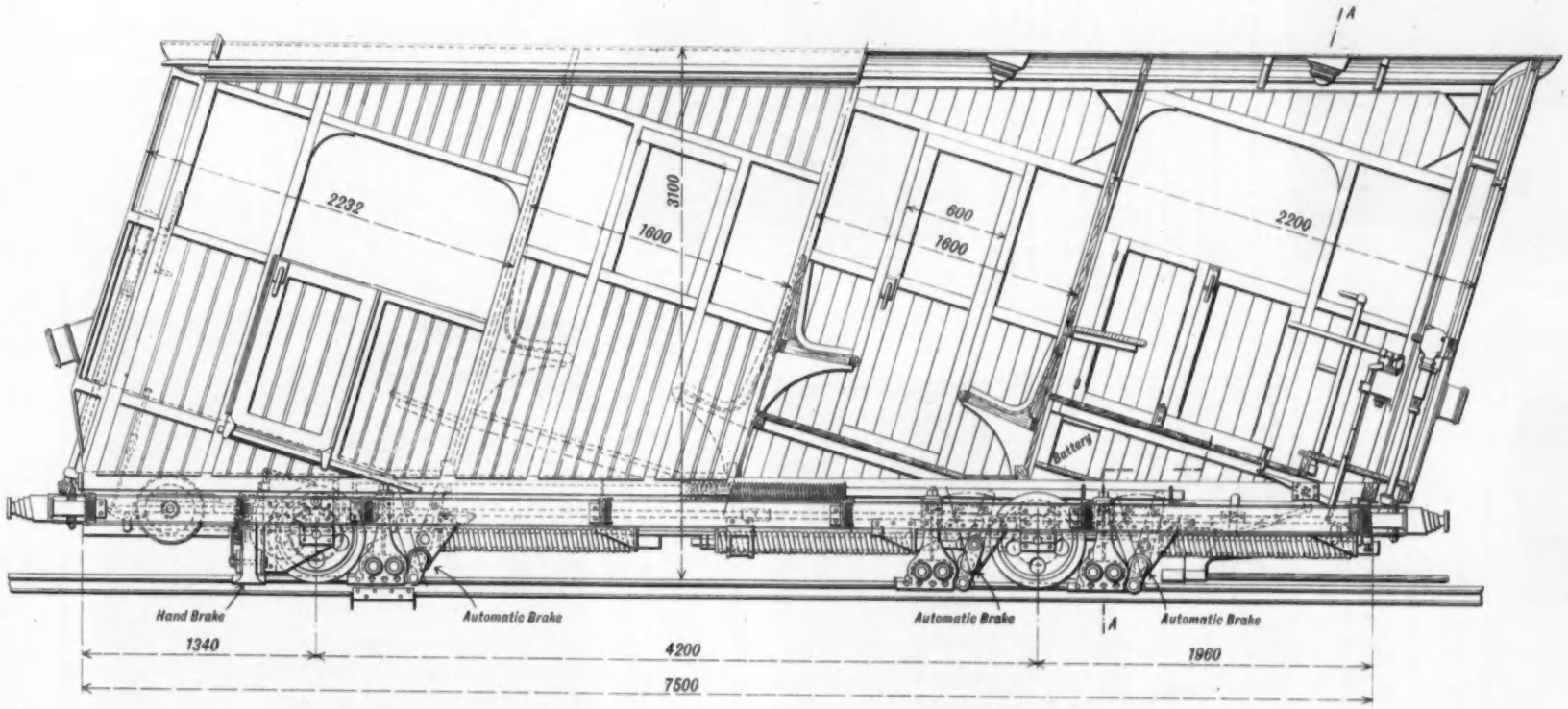
dried from contact with the elements, but allows the greatest possible amount of heat to reach the drying space. When these ovens are used for drying filter papers three horizontal rods are provided for supporting the papers. The particular oven illustrated is rated at 1 kW and is designed for use on a 230-volt supply.

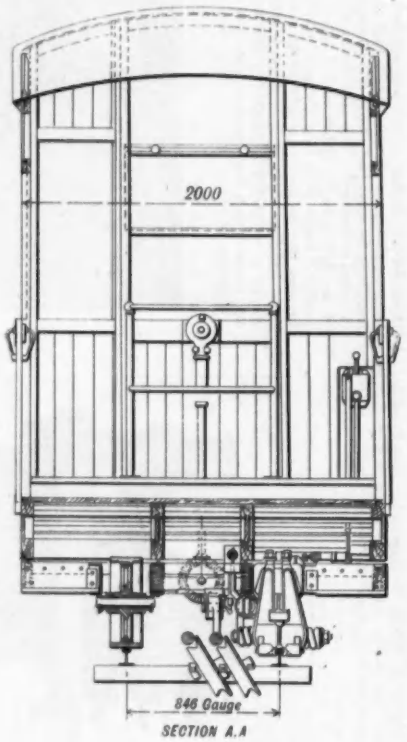
IN the course of his presidential address to the Institute of Fuel, Sir David Milne-Watson said, in connection with the low-temperature carbonisation of coal, "a number of processes have been operated in the country, and although I should not like to claim that finality had been reached, I think it can safely be said that technically the successful treatment of coal by low-temperature processes is now thoroughly understood. The main arguments put forward by the advocates of this treatment of coal are the desirability of having a supply of smokeless fuel and a source of home-produced oils. On the financial side the happy ending is not, I fear, yet in sight. It is conceivable that those plants which are situated in a geographical position so as to secure a good quality slack at low prices and can command a good price for the coke produced will show a profit upon their operations. In those parts of the country at a distance from the coal-fields the difference in the price that has to be paid for coal and that received from the sale of coke and gas, does not appear to provide a sufficient margin to meet even operating expenses. Both the coke fuel and the rich gas of externally heated systems can at present be marketed without difficulty. The oils, however, have so far proved most disappointing in quality, and their return, as with ammonia products, is negligible, in assisting the costs of the treatment of the coal."

PASSENGER CAR FOR THE CHANTARELLA-CORVIGLIA CABLE RAILWAY AT ST. MORITZ

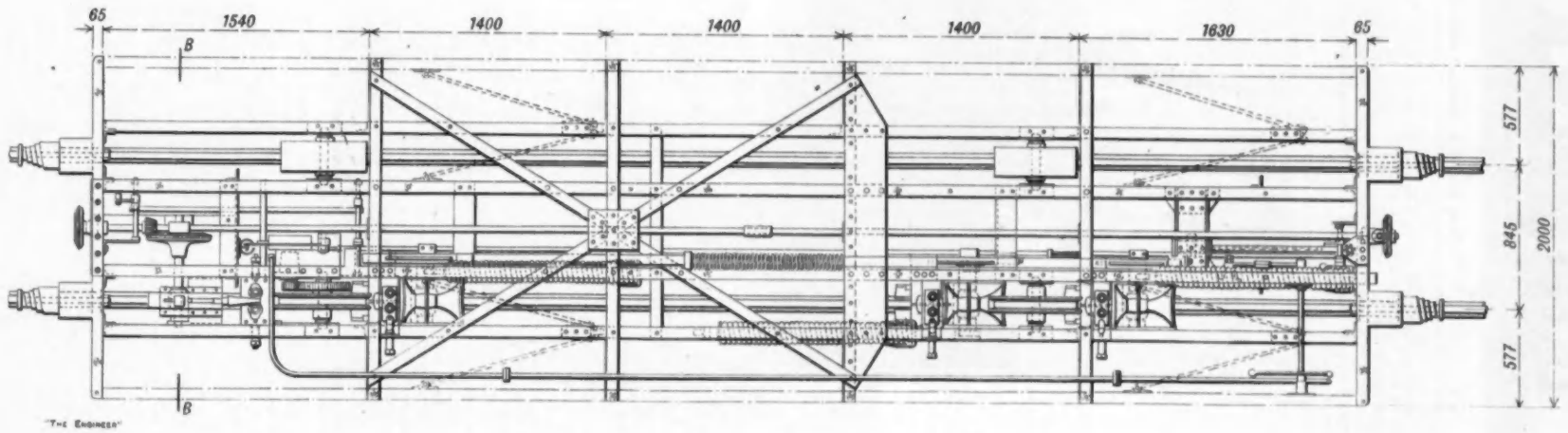
THEODORE BELL AND CO., KRIENS-LUCERNE, SWITZERLAND, ENGINEERS

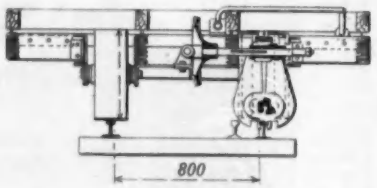
(For description see opposite page.)





SECTION A.A





SECTION B.B.

- All dimensions in millimetres -

"THE ENGINEER"

The Chantarella-Corviglia Cable Railway at St. Moritz.

No. I.

AT the present time, when many British people are looking forward to some weeks of sunshine and winter sports in one of the many Alpine resorts, it is not inappropriate that we should give a technical description of the new Chantarella-Corviglia cable railway at St. Moritz, which has been constructed by the engineering works of Theodore Bell and Co., of Kriens-Lucerne, Switzerland, in order to connect the village of St. Moritz with the Corviglia Hut. The description on which this article is based was prepared for us by the designer of the new railway, Mr. H. A. Peter, a civil engineer and Reader on Special Railways at the Technical High School, Zurich. We are also indebted to Mr. C. Campart, of Raymond House, 32–34, Theobalds-road, Messrs. Theodore Bell's London representative, for assistance given to us during its preparation.

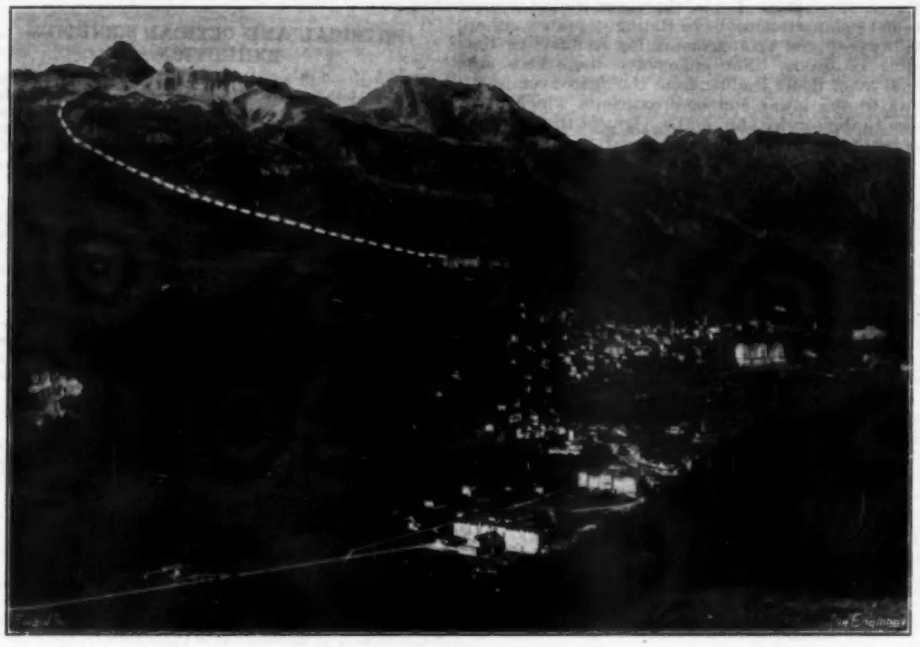


FIG. 1—VIEW OF ST. MORITZ SHOWING THE RAILWAY ROUTE

POSITION OF THE RAILWAY.

The Upper Engadine village of St. Moritz on the Rhætian Railway, Switzerland, which is deservedly known for its spa and winter sports facilities, was mentioned as a health centre by Paracelsus as early as the year 1535. Since 1871 it has attracted, both in winter and in summer, an increasing number of guests, and the number has been greatly enlarged since the war.

The new railway we are about to describe owes its conception to Colonel E. Thoma-Badrutt, who also initiated the construction of the Chantarella cable railway and the Chantarella Kurhaus. As the accompanying illustrations show, the new cable railway has been built on the northern side of the St. Moritz valley, and it has opened up new and extensive skiing fields, which even in the early mornings of November and December are in full sun and remain so throughout the day. Before the cable railway was built, over two hours were required to ascend to the height of the Corviglia Hut, whereas now it can be reached in the very short time of a quarter of an hour from St. Moritz, or in less than nine minutes from Chantarella, between which places there was a cable railway before the new line was constructed. While this region is of particular interest for winter sports, the Corviglia Hut also forms a good starting point for mountain tours in summer, and gives fine views of the Inn, Suvretta and Bevers valleys and of the mountain peaks which encircle it. In the view which we reproduce in Fig. 1 above, and which was taken last summer, the general route is indicated, and two typical views of the railway taken during the winter are given on page 680.

Principal Railway Particulars.

Horizontal length	1572·07 m.
Inclined length as measured	1650·22 m.
Height above sea level at Chantarella Station	2008·60 m.
Height above sea level at Corviglia Station	2489·21 m.
Total rise	480·61 m.
Maximum gradient	46 per cent., or 1 in 2·2
Gauge	0·80 m.
Minimum radius of curves	200·0 m.
Seating capacity of cars	60 persons with skis
Speed of car	3·2 m. per second, or about 7·2 m.p.h.
Time of single journey	8½ minutes
Number of passengers per hour each direction	360

In Fig. 2 we give at the top a profile of the line with its gradients and curves, while below it are three areas indicated by the letters "*a*," "*b*," and "*c*." The area "*a*" shows the variations in the pull exerted by the driving wheel of the haulage gear when a loaded car is going up and an empty car coming down, while the area "*b*" shows the variations in pull experienced when one empty car is going up and another empty car is coming down. The conditions when an empty car is going up and a loaded car coming down are shown by the area "*c*." We may remark upon the high car speed of 3·2 m., or 10·5ft. per second, which is maintained on the heavy gradient of 1 in 2·2 over a length of over 182 m. The running is, we understand, smooth throughout the trip, and punctuality is maintained so that the railway has a noteworthy passenger-carrying capacity.

DESIGN PROBLEMS.

The station of Chantarella—see Fig. 3—lies about 50 m. east of the upper station of the older St. Moritz-Chantarella cable railway, already referred to. During the recent summer the two stations were combined into one under a single roof, which has greatly increased the facilities available to passengers. Starting from Chantarella, the line proceeds for the first 450 m. through woodlands, taking an "S" shape curve and passing behind the Kurhaus, then running straight to the west, crossing the Alp Nova-Alpina roadway at an inclined length of 345 m. and the road to the Alp Giop and Alp Nova at a length of 600 m. It proceeds from this point by a right-handed curve to just below the passing place for the two cars, which also lies as shown by the lower view, Fig. 6 on page 680, on a right-handed curve. The view we reproduce is taken looking in the direction of St. Moritz and Pontresina, and shows the meadows and alpine slopes of St. Moritz and the wooded character of the lowest section of the line. The upper part of the passing loop enters a 51-m. tunnel, the view from the top end of which we show in Fig. 4. It will be seen that the line proceeds across the face of the mountain in a long left to right "S" bend of some 300 m., most of which is carried on a masonry viaduct. Above this point the maximum gradient of 45·6 per cent., or 1 in 2·2, is reached, and the line ascends higher on a further right-hand bend under Sass Ronzol, lying to the north, finally reaching the plateau on which the Corviglia Hut has been built. A good view of the descending car near the upper station is reproduced in Fig. 5 on page 680, while on page 676 we show the arrangement of one of the cars.

The line was planned and laid out on a 1 to 1000 scale survey map, which covered the somewhat broken country traversed by the railway. In laying out the route the question of economical construction had to be borne in mind, as well as the fact that the railway, which lies at a height of between 2000 m. and 2500 m. above sea level, has to be worked during the whole of the winter season. For that reason the upper portion of it was built entirely on embankments with bridges and viaducts. The diagram reproduced in Fig. 2 gives the principal gradients, which are respectively 15, 26·5, 29·7, 45·6, and 34 per cent. Such gradients would have been regarded by some authorities as being theoretically quite unsuitable for a cable railway because they do not give the requisite profile for a constant load resistance, which would render economical working impossible.

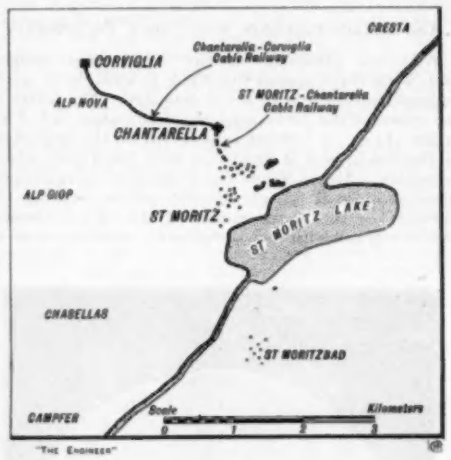


FIG. 3

In practice, however, the gradients and their changes were set out very simply in the form of parabolas, the lengths of the curves between changes in gradient being determined by the following formula of Mr. H. A. Peter, who has contributed much to the theory* and practice of cable railway construction. The formula used is

$$l \geq \frac{T\alpha}{p} \cdot \frac{\tan\beta - \tan\alpha}{1 + \tan^2\alpha}$$

where tan α and tan β are the gradients to be connected, *p* the maximum cable pull in kilogrammes measured at the lower end of the connecting or

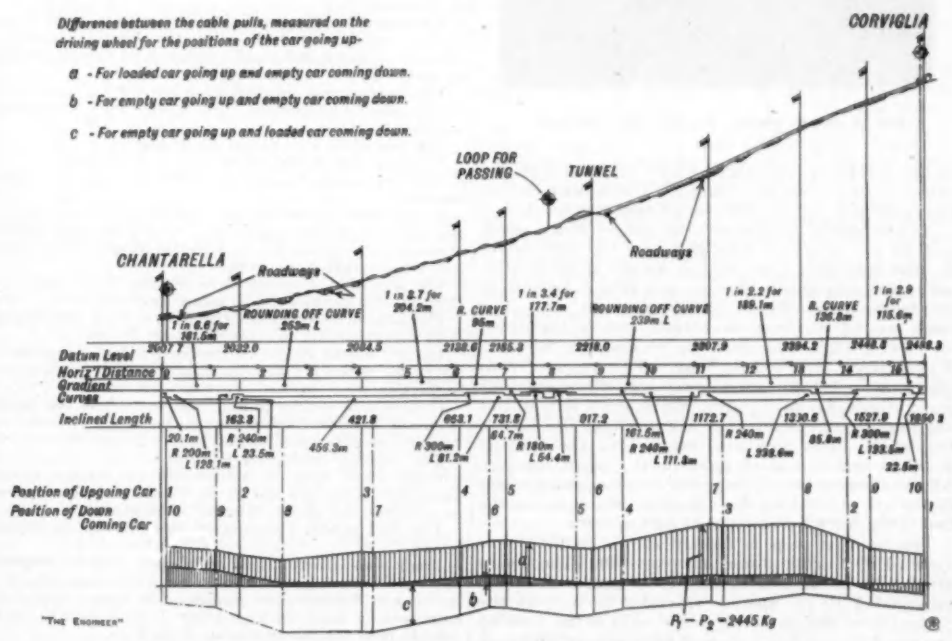

Difference between the cable pulls, measured on the driving wheel for the positions of the car going up-
a - For loaded car going up and empty car coming down.
b - For empty car going up and empty car coming down.
c - For empty car going up and loaded car coming down.
CORVIGLIA
LOOP FOR PASSING
TUNNEL
CHANTARELLA
Roadways
Roadways
ROUNDING OFF CURVE
ROUNDING OFF CURVE
R. CURVE
R. CURVE
Datum Level
Horiz. Distance
Gradient
Curves
Inclined Length
Position of Upgoing Car
Position of Down Coming Car
"THE ENGINEER"
P1 − P2 = 2445 Kg

FIG. 2—PROFILE OF LINE AND CABLE TENSIONS

* See "Schweizerische Bauzeitung," Vol. 83, No. 5, 1924.

"rounding-off" curve, while T α is the weight of the cable per metre run in kilogrammes, and l the horizontal length of the rounding-off curve. The radius of the curves was, for important reasons, kept within 200 m., except that of the passing loop, which for a short distance only is as short as 180 m., in spite of the small gauge of 0·80 m. This choice of curve is in contrast with the opinion held by many continental engineers that, apart from such factors as gauge, speed, size of car, layout of the line, type of brake and rolling stock, and kind of cable, a radius of curvature of 75 m. or even less is admissible. Taking the whole length of the railway, 49 per cent. of the inclined portion is on curves, about 46 per cent. on rounding-off curves, and another 18 per cent. on combined curves and gradients. The terminal stations are set at an angle of 56 deg., and the average radius of curvature of the whole line is 494·1 m. measured horizontally.

TRACK CONSTRUCTION AND CABLE EQUIPMENT.

With the exception of two small steel bridges, each with three spans, the track is built on a raised embankment of quarry stone masonry. The width at the crown of the permanent way foundation is 1·2 m., or 3ft. 11⅜in. A footway is provided for the inspection of the track, and is furnished with hand rails where necessary. About 50 cm. below the top of the sleepers there is a small trough for the cables carrying the current for the transformers at the upper station. The troughs are furnished with side openings to allow

FIG. 4—VIEW FROM MOUTH OF TUNNEL

of the escape of any water which may enter it and to provide facilities for cleaning. The railway crosses five footways, and all of them are taken under it.

As previously mentioned, the gauge of the track is 0·80 m., or about 2ft. 7½in., and the rails are of the flat-bottomed type, with a weight of 20·6 kilos. per metre, a height of 100 mm. and 46 mm. breadth at the head, a breadth at the foot of 90 mm. The rails are 10 m. long, and each rail is supported on eleven angle-iron sleepers, 90 mm. by 90 mm., 9 mm. thick and 1·2 m. long. Two pairs of fish-plates are used for each joint and there are four pairs of intermediate plates, which serve to transmit the braking stresses to the sleepers and the bed of the track. The rails are fastened to the sleepers by clips and T-headed bolts in the usual manner. All the sleepers below the joints and the intermediate plates are secured to the masonry, which forms the bed of the track by two special anchor bolts.

The passing loop is clearly shown in the lower view—Fig. 6—reproduced on page 680. The tracks are 93·33 m. in length, and their centre lines are arranged 3·10 m. apart. In order to support the cables, there are, as shown to the right of the drawing on page 676, cast iron rollers of light section, which are arranged in pairs so as to take the vertical and side loads. All the rollers are fitted with ball bearings, which have greatly reduced the amount of inspection necessary and the friction losses. The cable has a diameter of 31·7 mm., or nearly 1¼in., and is of Lang's lay, having six strands and a hemp core. It weighs 3·1 kilos. per metre, and its tested breaking strength is 52 metric tons. Each strand is built up of seven inside wires, each having a diameter of 1·53 mm. and eight outer wires of 2·71 mm. diameter. The average breaking strength of the wire is 147 kilos. per millimetre, and the extension at the breaking load 3·5 per cent. The tests carried out on the cable and the wires forming the strands fully met the official Swiss regulations.

THE PASSENGER CARS.

On page 676, we reproduce a drawing of one of the two passenger cars, from which it will be seen that there are two closed centre compartments and two open-end compartments, which are, however, protected from wind and weather by windows and sail cloth screens. In each of the middle compartments seating is provided for eight persons with standing room for a further four passengers. The end compartments contain the conductor's control platform and also space for goods and skis, and, in addition, there are tip-up seats for four passengers. The two centre compartments have adjustable windows, while on the left-hand side there are sliding doors. The end compartments have sliding doors on either side, with special arrangements for facilitiating the loading of goods. For emergency use, there are special inner doors leading from the centre compartments to the lower end compartments which give access to the service step on the right of the railway. The left-hand doors are so arranged that they can be locked altogether from the conductor's platform, while there are separate locking arrangements for the emergency doors. The car is sprung in the usual manner, and is furnished with buffers at both ends. The overall frame length is 7½ m. and the frame width 2 m., while the wheel base is 4·2 m. Each car has a designed capacity for thirty passengers with skis, weighing, say, 80 kilos. per person. The weight of the car empty is 5300 kilos., and when fully loaded 10,100 kilos. For the lighting of the four compartments and the headlights a nickel iron battery is provided. The braking equipment, to which we propose to refer in detail in our next issue, includes hand-operated brakes, worked from both ends of the car, and three fully automatic brakes of the Bell patented type, which come into operation when the speed of the car exceeds the designed maximum speed of 3·2 m. per second, by 45 per cent., or when the cable breaks or loses its tension.

In our second article we shall also deal with the hauling machinery at the upper Corviglia station, and the official trials carried out on the railway.

(To be continued.)

The British Industries Fair.

THE recommendations of the Committee appointed by the Board of Trade, under the chairmanship of Viscount Chelmsford, to examine the present situation as regards the British Industries Fair and to consider what means can be adopted to increase still farther its utility to British trade, are as follows :—

Charges for space should not be increased for the purpose of contributing towards advertising expenses.

The Government's publicity grant should be established and increased to a minimum of £100,000.

A special committee should be set up to direct the expenditure of the publicity grant, the administration of which should remain under the control of the Department of Overseas Trade.

The overseas officers of the Department of Overseas Trade should be consulted by the special committee referred to above and should visit the Fair as frequently as practicable.

The Government banquet to celebrate the opening of the Fair should be continued and, if possible, supplemented by other functions.

The date of the Fair should not be altered.

A second Fair should not be held in the Autumn.

The Fair should be open on the Saturday of the second week.

A site easily accessible from central London should be acquired and equipped with buildings for the Fair capable of extension as required. A committee should be appointed to formulate definite proposals.

The allocation of industries as between the London and Birmingham Sections should generally stand.

The London Section should be open to the public during both Saturdays and on other days from 2 p.m.

Inquiry kiosks should be provided to put members of the public in touch with retail distributors of goods shown at the Fair.

Greater care should be exercised to exclude the public from the London Section during the hours reserved for trade buyers, for whom special badges should be provided.

The existing regulation relating to the eligibility of persons other than manufacturers to exhibit should generally stand, but should be relaxed in certain cases as recommended by the Warner Committee.

The Fair should continue to be restricted to British goods.

Trade associations should collaborate with the Department of Overseas Trade with a view to the more effective layout and decoration of Sections. An expert should be employed by the authorities of the London Fair to assist exhibitors in the better display of their goods.

The Fair authorities, the Travel Association of Great Britain and Ireland and other interested bodies should collaborate to provide hospitality and assistance for overseas buyers.

Every effort should be made to increase the number of overseas buyers attending the Fair.

The free passport visa granted to foreign buyers attending the Fair should be made available for at least three months and should cover return visits to the United Kingdom during that time.

Careful consideration should be given to the inclusion in the Fair of an exhibit of industrial art with a view to the improvement of design in certain classes of manufactured goods.

The question of holding the Fair, or sections of it, abroad should be referred to the Committee on British Participation in Overseas Exhibitions and Fairs.

Specially selected officers should be continuously employed in the administration of the Fair.

The management of the London Section by the Department of Overseas Trade should be maintained.

The Fair should be developed—and this is the basic recommendation of our Report—so as to become a truly national manifestation of the quality and range of British products and an increasingly powerful factor in the expansion of our trade. The Government and manufacturers generally should accord it more vigorous support, and the public should be encouraged to learn through the Fair that British manufacturers can supply their needs.

The full report can be obtained from H.M. Stationery Office, price 6d.

PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION.

THE twenty-first annual Exhibition of the Physical and Optical Societies is to be held on Tuesday, Wednesday, and Thursday, January 6th, 7th, and 8th, 1931, at the Imperial College of Science, Imperial Institute-road, South Kensington, and will be open in the afternoon from 3 p.m. to 6 p.m., and in the evening from 7 p.m. to 10 p.m. This being the twenty-first Exhibition, Professor Sir Arthur Eddington, F.R.S., has consented to mark the occasion by performing an opening ceremony on Tuesday, January 6th, at 2.30 p.m. Over eighty firms have accepted the invitation to exhibit in the Trade Section at this Exhibition. A group of research and experimental exhibits is also being arranged, and some interesting historical exhibits will be included.

Two discourses, with experiments, will be given at 8 p.m. on the second and third days, as follows :—January 7th, Mr. E. Lancaster-Jones, "Searching for Minerals with Scientific Instruments"; January 8th, Professor Sir Gilbert Walker, F.R.S., "Physics of Sport."

A section of the Exhibition is again to be devoted to the work of apprentices and learners, in competition, and the Councils of the Physical Society and Optical Society have appointed the following judges :—Dr. C. V. Drysdale, Professor A. F. C. Pollard, Sir Thomas Stanton, and Mr. William Taylor.

We understand that invitations to the Exhibition have been sent to the Institution of Electrical Engineers, the Institution of Mechanical Engineers, the Royal Aeronautical Society, the Royal Meteorological Society, the Faraday Society and a number of other societies and bodies. As in previous years, members of these societies should apply for tickets to their secretaries. Others may obtain tickets on application to the secretary, the Physical and Optical Societies, 1, Lowther-gardens, Exhibition-road, London, S.W. 7. Tickets are required only on January 6th and 7th. Admission on the third day, January 8th, will be without ticket.

B.E.S.A. SPECIFICATIONS.

WHEEL RIMS AND TIRE BANDS FOR AUTOMOBILES.

A REVISED edition of the British Standard Specification for Dimensions of Wheel Rims and Tire Bands for Pressed-on Tires for Automobiles has recently been issued by the British Engineering Standards Association. The principal revision consists in the elimination of the 740 mm. size of rim and the inclusion of 26in., 28in., 30in., and 34in. sizes. Copies of this Specification, No. 71–1930, can be obtained from the British Engineering Standards Association, Publications Department, 28, Victoria-street, London, S.W. 1, price 2s. 2d. post free.

AN APOLOGY.

WE have been asked to publish the following letter, dated December 6th, and addressed to H. W. Kearns and Co., Ltd., Broadheath, Manchester, and to Geo. Richards and Co., Ltd., also of Broadheath, Manchester :—

> Dear Sirs,—We beg to send this letter of apology for having supplied horizontal surfacing and boring machines equipped with travelling spindles and automatic facing heads which were, as you suggested, in conflict with certain patents held by yourselves.
>
> We are having the facing heads removed from these machines and appreciate your willingness to supply heads of your own make to replace these, if this is possible.
>
> As per our conversation, we are agreeable that this letter should be printed in the technical Press.—Yours faithfully, THE SELSON ENGINEERING COMPANY, Ltd.
>
> (Signed) H. M. Selson,
> Managing Director.

ERRATUM.—In our description of the 1000 B.H.P. Crossley-Premier *vis-à-vis* oil engine, given in our issue of December 5th, the fuel consumption was given on page 622 as being 0·38 lb. per square inch. It should, of course, have read 0·38 lb. per B.H.P. hour.

MANCHESTER ASSOCIATION OF ENGINEERS.—Probably the most successful evening's entertainment which the members and friends of the Manchester Association of Engineers have ever enjoyed was given by the president, Mr. G. E. Windeler, M.I. Mech. E., and Mrs. Windeler, at the College of Technology, Manchester, on Friday, December 12th. In addition to an excellent musical programme and dancing, the visitors, numbering over 700, had an opportunity of inspecting the engineering laboratories and workshops, textile departments, and printing and bookbinding sections, which were kindly thrown open by the College authorities.

INSTITUTION OF MECHANICAL ENGINEERS.—The Graduates' Section of the North-West Branch of the Institution of Mechanical Engineers held its annual dinner on Saturday last at the Engineers' Club, Manchester, when a very enjoyable evening was spent. Mr. R. L. Gregson, graduate, presided, and Mr. H. L. Guy, chairman of the branch, was the principal guest. In an admirable address to the graduates, Mr. Guy complimented the section on its success, and especially commended the good work of two of its members in gaining the Council's awards for papers contributed during last session. Dinner was followed by a smoking concert.

Railway and Road Matters.

THE Parliamentary Notice of the Metropolitan District Railway includes a proposal for the enlargement of the tunnels at each end of Sloane-square station, presumably for the lengthening of the platforms.

As it was only as recently as October 17th last that we recorded the retirement of Sir Arthur Yorke, for many years a Board of Trade Inspecting Officer of Railways, from the Great Western directorate, we are particularly sorry to hear of his death on December 10th.

THE scheme to provide Montreal with a rapid underground transportation system at a cost of 65,000,000 dollars has now assumed the shape of a definite project, and the immediate building of 8 miles of subways is proposed. Five years will be required for the work.

RECENTLY a question was addressed to the Minister of Transport as to whether he would introduce legislation to enforce complete amalgamation of the railway companies with a view to economy of expenditure and the reduction of industrial friction. Mr. Morrison, in reply, said that he proposed to await the issue of the final report of the Royal Commission on Transport before considering the question of legislation on that subject.

THE electrification of the Manchester South Junction and Altrincham Junction Railway, jointly owned by the L.M. and S. and L. and N.E. companies, is making progress. The line runs from London-road station, Manchester, to Altrincham, a distance of 8¾ miles, and the work is, we understand, completed for the 5 miles from Old Trafford to Timperley, and trial trains are now running. Power is conveyed by overhead construction and the voltage is 1500. The carriages are of the compartment type.

THE appointment of Sir Ralph Wedgwood, the chief general manager of the London and North-Eastern Railway, to act also as a member of the Central Electricity Board, was mentioned in this column of our issues of October 17th and 24th. When it was suggested recently in the House of Commons that the manager of a railway had sufficient to occupy his time in the supervision of a big line, Mr. Morrison replied that it was very essential that the railways should be associated with the Central Electricity Board.

THAT picturesque line of the Great Western, known as the Vale of Rheidol, which runs from Aberystwyth to Devil's Bridge, is to be closed for goods traffic on January 1st. The official notice adds that it will be closed against passenger traffic also "until further notice." That proviso suggests that it may be open for the latter purpose in the summer. The Carris branch, powers to acquire which were only obtained last session, is to be closed for passenger traffic. The former railway is remarkable in that it has a gauge of 1ft. 11¼in.; the gauge of the Corris is 2ft. 3in.

THE Ministry of Transport railway statistics for September have recently been issued as a Stationery Office publication, price 3s. 6d. They show that, compared with September, 1929, there was a falling off of 3·4 per cent. in the number of passenger journeys and of 8·1 per cent. in the receipts from passengers. Despite that fact, the passenger train mileage rose by 1·7 per cent. The tonnage of freight traffic decreased by 9·9 per cent., and the freight traffic receipts by 7·7 per cent. There was a drop of 2·5 per cent. in the freight train mileage and the average train load fell from 132 to 125¾ tons, and the net ton-miles per engine hour from 457¾ to 451¾.

THE Railway Returns for 1929 show that of the 2064 locomotives owned by the Southern Railway, the average daily number available for use was 75·05 per cent.; of those available 91·95 per cent. were used. Of the 3908 locomotives on the Great Western, 77·32 per cent. were available and 96·04 per cent. of that number were used. The London, Midland and Scottish had 82·92 per cent. of its 9879 locomotives available, and 90·77 per cent. of them were used, and of the 7411 on the London and North-Eastern 79·94 per cent. were available and 89·58 per cent. of that number were used. Of the totals of locomotives owned, as quoted above, the maximum numbers in use on any one day were:—Southern, 1613; Great Western, 3124; London, Midland and Scottish, 7753; and London and North-Eastern, 5597.

AN analysis of the signal statistics, quoted on page 649 of our issue of December 12th, from the Automatic Train Control Committee's report, shows that the four grouped companies—named in the following order, Great Western, Southern, London, Midland and Scottish, London and North-Eastern—have a signal-box to every 2·86, 3·23, 2·27 and 3·06 track miles; a distant signal for every 1·14, 1·26, 0·83 and 1·22 track miles, and a stop signal for every 0·48, 0·52, 0·42 and 0·47 track mile. The close proximity of the last figures to each other is interesting. But more remarkable still is the little difference in the number of stop signals to each motive power unit, *i.e.*, motor coaches as well as locomotives. The four averages under that heading are 2·22, 2·41, 2·27 and 2·31. It should be noted that these figures do not represent the number of signals themselves, but the number of signal positions, *e.g.*, the two signals at a junction are counted as one.

THE last quarterly blue book on railway accidents contains the report of Mr. J. L. M. Moore, one of the Assistant Inspecting Officers, on the fatal injuries to a platelayer working in a tunnel owing to his clothing being set on fire from a naphtha lamp. The unfortunate man and his ganger had to clean and refill the naphtha lamps used by the gang who were relaying and the accident happened whilst a train was passing. Mr. Moore remarks that it draws attention to the danger of utilising lamps of this nature, which not only have a naked flame, but are apt to drop burning oil, to give light to men who are handling an inflammable fluid such as naphtha. He understands that the question of providing special lights for use whilst naphtha lamps are being filled has been under consideration for some time, and it is to be hoped that, in view of this regrettable occurrence, a decision will soon be reached and more suitable lamps provided at an early date.

Notes and Memoranda.

THE number of furnaces in blast fell by four during November to ninety-two. Production of pig iron in November amounted to 384,100 tons, compared with 415,000 tons in October and 631,400 tons in November, 1929. The production included 107,500 tons of hematite, 143,600 tons of basic, 102,500 tons of foundry, and 18,000 tons of forge pig iron. The November output of steel ingots and castings amounted to 433,700 tons, compared with 512,500 tons in October and 815,000 tons in November, 1929.

A CURIOUS old bridge over the Wabash River at Vinciennes, Ind., U.S.A., is to be replaced by a modern structure. The original bridge, which was built in 1868, had four spans of about 150ft. each of lattice timber trusses, and a central bow-string opening span. In 1875, two of the trusses were replaced by steel spans. Later the other two spans were replaced by steel and finally the swing span changed to two fixed girders. A sketch is given in the *Engineering News-Record* of the reinforced concrete bridge, which it is proposed to put in the place of the old crossing.

STOPPAGE of a 1in. lead service pipe under pressure by the growth of tree roots was, says the *Engineering News-Record*, recently observed at Detroit, Mich. The service was originally installed more than thirty years ago. It was provided with a branch for a sprinkler connection, but twenty years ago, during repair of a leak, the branch was cut off and plugged with a wooden plug. A complaint of short supply was recently investigated, and it was discovered that the plug had almost completely rotted away, and that tree roots had entered the opening and grown to a length of about 2ft., stopping the line almost completely. The roots were removed and the end of the branch was carefully closed to prevent further trouble.

A RATHER unusual form of boiler explosion is described in the Board of Trade official report No. 3099. It concerns a Lancashire boiler at a Durham colliery. The actual explosion was not of a very disastrous character, but it was violent and was caused by the collapse of one of the flues about 1 foot square. The reason ascribed to this collapse is that a defective patch of welding on the opposite side of the flue allowed a jet of steam to escape and, passing across the flue, to impinge on the plating on the opposite side. This jet eroded away the plate to such an extent that it could not support the working pressure. The Engineer Surveyor-in-Chief makes some comments on the necessity for welding operations on boilers being carried out by competent workmen and under proper supervision.

ALTHOUGH titanium was discovered 141 years ago, it is only within the past ten or fifteen years that any extensive use for its ores has been found. Titanium ranks as one of the more abundant elements, is widely distributed, and occurs in concentrated form in numerous deposits. Ferro-alloys containing the element were largely used for a time, especially in connection with the manufacture of Bessemer steel rails; but as American railways adopted open-hearth rails in preference to Bessemer rails, the demand for the alloys in the rail manufacture gradually dwindled into insignificance. New outlets for ferro-titanium have been found in the steel industry; and the production of titanium alloys, both in the United States and in Europe, has increased in recent years. By far the largest use of titanium at the present time is in pigments.

IN a recent address on the brown coal resources of Victoria, Sir John Monash, Chairman of the State Electricity Commission of Victoria, declared that within the near future the brown coal briquettes produced by the Commission would take the place of black coal in Victoria for all purposes, excepting gas making. In the six years since the undertaking at Yallourn was established, the power of the generating plant had increased from 30,000 H.P. to nearly 200,000 H.P. This development had been rendered necessary by the growing public demand, due to the largely increased use of electrical appliances of all kinds. Around Morwell the brown coal deposit was 30 square miles in area, and as 1 square mile of this area would suffice to serve the needs of Victoria for somewhere about 1000 years, the resources of the State were substantially unlimited.

THE advantages of the welded bed-plate over the casting may, states the *Welder*, be briefly stated as follows:—(1) No patterns are required, and in cases where fresh designs are being made a considerable loss of time is thus eliminated. (2) A lighter article is produced. Comparative figures from a number of different works show that the average saving in weight between a welded and a cast iron bed-plate is approximately 15 per cent. for small bed-plates and up to 25 per cent. for large ones. (3) Rigidity can be obtained without having to add heavy masses of metal. The discreet use of gussets and stiffeners welded rigidly in the correct place will produce as rigid a structure as any casting can give with the minimum amount of metal. (4) The welded steel bed-plate is very much less liable to damage than a cast iron bed-plate. This is more particularly the case where the bed-plate is for use with a portable plant.

A RECENT bulletin of the American Bureau of Mines describes a method for testing the relative strength of iron ores. Previous investigations have shown that the physical condition of the material in the burden of a blast-furnace affects the mechanical operation as well as the efficiency of the furnace. Two lots of about 150 lb. each were prepared from each ore after it had been screen-sized. One lot was rolled in a small batch-type rotary kiln for 1½ hours. The ore was removed and screened. Changes in the screen analyses were considered to have been due to mechanical work at room temperature. The other lot was rolled in the same kiln for 1½ hours, during which time the temperature was increased from room temperature to 1400 deg. Fah. The ore was removed and screened. Changes in the screen analyses were considered to have been due to both mechanical work and temperature. Tests on 34 ores indicated that the screen analyses of the ore was not a true measure of its mechanical strength. The average decrease in average particle size was 18 per cent. due to cold work and 38·1 per cent. due to hot work.

Miscellanea.

WORK was started in the middle of November on the construction of the steel works of Dorman, Long and Co. at Germiston, South Africa.

THE Government steel works at Yawata have decided to cut down the output of heavy rails as the last measure for meeting the great decrease in orders for such rails in the second half year, but the amount to be reduced is not yet fixed. For this fiscal year the estimated output of heavy rails at Yawata was 130,000 metric tons, of which 70,000 tons were delivered to the buyers; but of the remaining 60,000 tons to be produced in the second half year, the orders from the Japanese Government were only about 8000 tons.

THE largest commercially-operated wind tunnel in existence has been completed at the plant of the Berliner-Joyce Aircraft Corporation near the new municipal airport at Dundalk, Maryland, U.S.A. By means of the air tube, the engineers of the company will be able to determine the performance and stability of all planes they plan to build by measuring the forces and moments on exact scale models in the wind stream. The tunnel equipment was completely electrified by the General Electric Company of New York.

THE official returns rendered to the Electricity Commissioners show that 1035 million units of electricity were generated by authorised undertakers in Great Britain during the month of November, 1930, as compared with 1005 million units in the corresponding month of 1929, or an increase of nearly 3 per cent. During the eleven months of 1930 up to the end of November, the total amount of electricity generated by authorised undertakers was 9719 million units, as compared with 9245 million units for the corresponding period of 1929, representing an increase of over 5 per cent.

THE vice-president and general manager of the Beauharnois Power Corporation recently stated that during the last eleven months operations had exceeded expectations, the excavation equipment having exceeded its rated capacity and handled the material at a cost below the estimates. About one-third of the material which must be removed for the 200,000 H.P. initial installation has been excavated. The electric hydraulic dredger which is carrying out the largest proportion of the excavation required in the undertaking has completed about one-half of its work. There are about 2422 men on the pay roll.

SPEAKING at the annual dinner of the Royal Geological Society of Cornwall at Penzance, Captain F. C. Cann, manager of Geevor Mine, St. Just, said that while many held that they would have a prolonged period of depression in Cornish mining, he himself thought the younger generation would see Cornwall as a tin-producing county far in excess of what it had ever been. The world depression at the present time had been brought about through dredgers working on alluvial tin, mostly in Malaya and in Siam, and they knew that the life of those deposits was very short compared with the mineral deposits in Cornwall.

WORK is proceeding on the excavations for the new hotel, to contain 900 bedrooms, which will occupy a site of 56,000 square feet near the Marble Arch. This hotel, which will be completed in the early part of 1933, will be owned jointly by J. Lyons and Co., Ltd., and the Strand Hotel, Ltd., and a separate company is being formed for the purpose. The steel frame, which is being manufactured and erected by Dorman, Long and Co., Ltd., will weigh over 10,000 tons, and deliveries are expected to begin early in January. There will be eight floors and a roof above ground level, and, in addition, a basement and sub-basement. Owing to the large size of the site, nearly 3000 tons of steel will be employed before the building reaches ground level. The new tube railway station will be incorporated in the main entrance in Oxford-street, and a large booking hall, for which Dorman, Long and Co., Ltd., have also supplied the steel work, is at present being constructed underneath Oxford-street.

THE Montreal Board of Trade at a meeting held on November 26th, after a lengthy discussion, adopted a resolution approving the principle of the St. Lawrence waterways improvement project, but expressing the opinion that the whole project should not be undertaken at one time or any substantial part of it immediately; that the development of power in the national and international sections of the river should be proceeded with as and when required; that the approval of the Dominion Government being given only to such power projects as would provide navigation channels; that the cost of power and navigation development should be separate, the former financed by users of the power; that none of the power generated in the Canadian section nor Canada's portion of power generated in the international section be exported; and that when the improvement of the St. Lawrence system is proceeded with the United States, which will reap the greater share of the benefit, should contribute proportionately in such a manner as will not alter or qualify the sovereignty of the Dominion.

DURING the past year the Electrical Department in Ceylon was exceptionally busy. Apart from the maintenance of electrical installations in Colombo and in all towns in the island, where electricity is installed, works of a special nature have been undertaken. According to *Indian Engineering*, work on the electrification of three towns has been actively pursued and in another three towns the work has commenced. The work on the new 33,000-volt transmission line has been vigorously pushed forward, and the construction of lines northwards to Negombo and southwards to Moratuwa is well in hand, including the necessary transforming stations. A new 3300-volt line has been installed to extend the Colombo supply to Dehiwala and Mount Lavinia. It should be recalled here that in May, 1927, it was decided that no new works in connection with the hydro-electric scheme should be started. Revised estimates have since been drawn up for the whole of the works in connection with the scheme and reports prepared. The first reading of the Hydro-Electric Loan Bill for the completion of the scheme was passed by the Ceylon Legislative Council in March last.

THE CHANTARELLA-CORVIGLIA CABLE RAILWAY AT ST. MORITZ

THEODORE BELL AND CO., KRIENS-LUCERNE, ENGINEERS

(*For description see page 677.*)

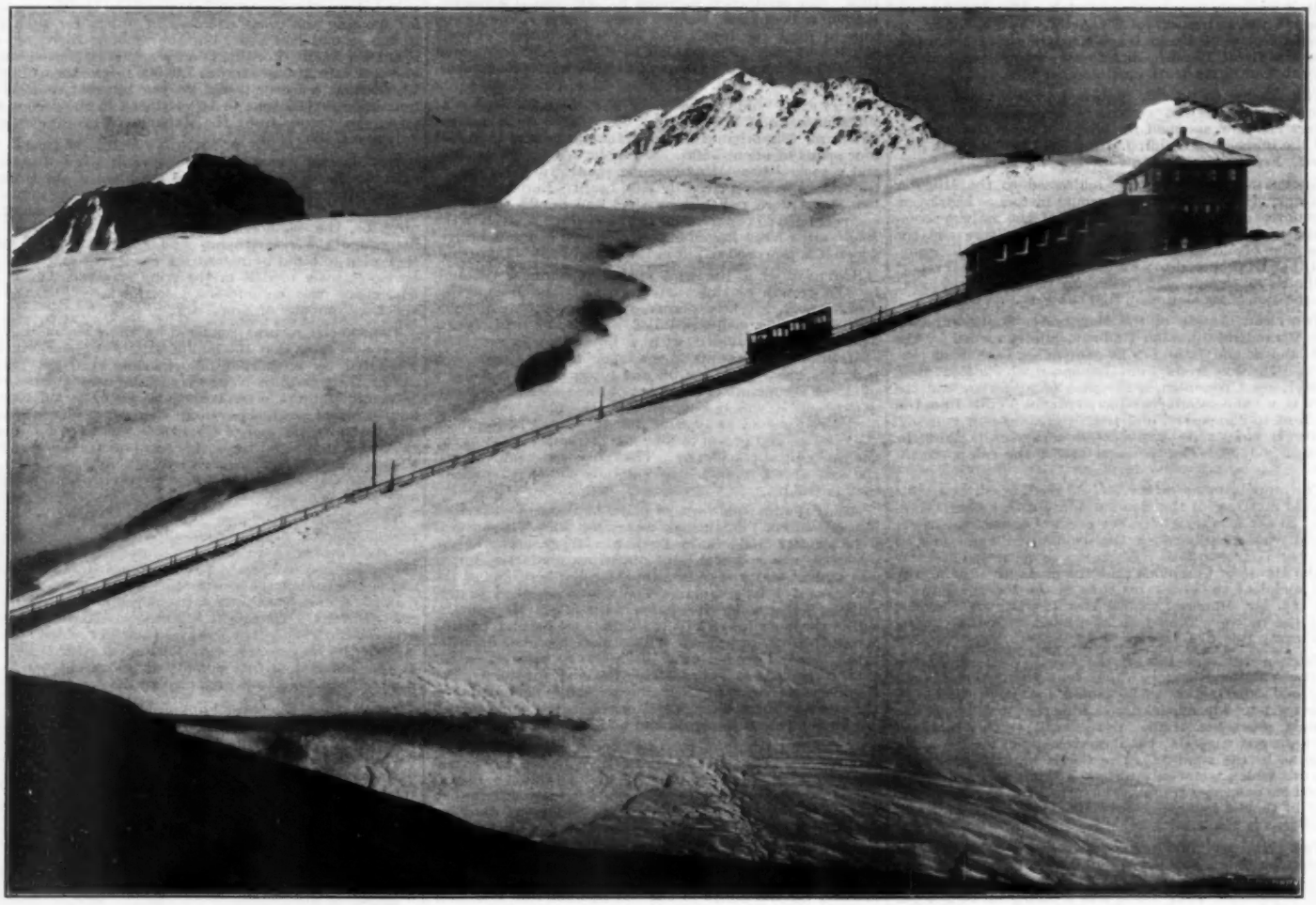


FIG. 5—THE UPPER STATION NEAR THE CORVIGLIA HUT

FIG. 6—VIEW FROM PASSING LOOP LOOKING DOWN ON ST. MORITZ

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THE ENGINEER.

VOL. CL No. 3910

DECEMBER 19, 1930.

Of Museums.

IN this utilitarian age pure learning is difficult to defend. Latin and Greek are nearly as dead as "the use of the globes." History is taught, not as a cultural subject, but with an eye to its use in industrial economics, and geography as part of a commercial education, not as a concomitant of "gentility." Euclid is almost forgotten because his elegant method is less practical than modern geometry, and the cult of letters is followed by the mass only as a step towards the solution of crossword puzzles. No one dares, now, to say that he learns French or Italian in order to give a finish to his education ; he acquires them for immediate use in business, and if he cannot sell his knowledge of them he counts the time and labour spent upon them as lost.

How, then, can we defend museums ? If we put to one side the service which they render to designers of new furniture and new fabrics—"new," but all too often to be made "old" by a process of weathering—there remains little that is not purely cultural. The study of antiquities, whether they be artistic or technical, architectural or domestic, has little value other than that of the elevation of the mind. The museum, unlike the exhibition, does not encourage trade ; it has little to do with man's material wants and has no concern with business. It is difficult indeed to find any arguments in its favour which would satisfy the utilitarian. Yet that is what Sir Henry Lyons set out to do in his Presidential Address to the Junior Institution of Engineers, for which he took the title "Technical Museums and their Value to Engineers." As Director and Secretary of the Science Museum at South Kensington, Sir Henry was able to give many interesting facts from personal knowledge of the wonderful national collection, and he pointed with gratification to the ever-growing public attendance ; but he found it difficult to show that our own technical museums or those of other nations are of direct value to engineers. We doubt, indeed, that engineers ever think of them in that way. Were a census of visitors taken we do not think it would be found that engineers formed even an important part of the whole attendance. If we exclude the small boys who use the galleries as playgrounds—what a blessing it would be if they were compelled to wear rubber shoes !—we suspect that the visitors would be found to consist of all sorts and conditions of men and women come to look and to wonder, to see the "wheels go round," to contrast the crudity of the past with the perfection of the present, or to marvel at the beauty of models—which have always a peculiar attraction—but lacking for the most part technical knowledge and quite indifferent to the possible useful applications of what they see. We should have to conclude that if we are to measure the value of museums to engineers by the same standard that is employed for technical exhibitions, it is very small indeed. But that is not to say that they are useless ; they have a distinct and proper value, one that very possibly is greater than the mere utilitarian can see. Sir Henry said very rightly that "It is the educative influence that is looked for in technical museums, and this is now very generally held fully to justify their cost." We may regard that "educative influence" as twofold. In part it is purely cultural. It has no ulterior motives and is not expected to lead to "useful" results. The ordinary lay sightseer at the museum is subject to this cultural influence ; his mind is broadened and enlarged by what he sees. But in part the influence is technically stimulating. It stirs the imagination. The mechanic who examines the devices which have been used by inventors, who studies intelligently the steps by which primitive mechanisms have advanced towards perfection, who sees the material difficulties with which pioneers had to struggle, cannot fail—if he has any powers of vision at all—to become, at least whilst he is under the influence, an inventor, or pioneer, himself. The great past is laid before him in perspective, and by degrees he finds himself turning his back upon the vanishing point in the distant past and looking towards the greater future where the things which he now sees as the ultimate development shall themselves become mere moats in the perspective, and, being an engineer, he wonders if he cannot contribute something towards that new age. Or it may be that, on a somewhat lower plane, the examination of devices employed by past inventors gives him a clue to a problem which has been vexing him. The study of mechanisms has almost lapsed in technical colleges. Other subjects have crowded it out, but of its value to engineers there can be no question at all. It is in the technical museum that the engineer has now the best opportunity for studying it, and the fact, mentioned by Sir Henry, that the attendance of students at the Science Museum tends to increase may be an indication of the natural hunger of the born engineer for mechanical devices. From time to time—beginning years ago—books giving outline sketches of such devices, of all sorts and kinds, have appeared. If such books could be made real, if all the mechanical devices could be exhibited in cases, and all shown in motion, the attraction to the "general" would be no less than the educative value to the mechanic. Imagine, for a single example, a case showing all the forms of the rotary engine illustrated in Reuleaux's "Kinematics," and consider what a valuable lesson in mechanisms it would present.

In the present year over one million people have visited the Science Museum at South Kensington, and the fact that the attendance on Saturdays is 50 per cent. above that of any other weekday, seems to indicate "that they are drawn from professional and industrial classes who are employed during the week." Sir Henry may be right in that conclusion, but whilst we should be glad to think that technical men are making more and more use of the Museum we submit that if it is looked upon in its right light as a cultural institution, it is even more important that the lay public should visit it. Not only must it help in the development of intelligence, but it cannot fail to augment the sympathy of the public with engineering and ultimately with science, upon which the material progress of humanity depends.

Akroyd-Diesel Engines.

IT is usual to open a memorial lecture with some reference to the person whose name is being celebrated. Following that course in his excellent lecture upon The Origin and Development of Heavy-oil Aero-engines, at the Royal Aeronautical Society on December 11th, Mr. D. R. Pye paid a tribute to the genius of Akroyd-Stuart, and then went on to compare his share in the development of the internal combustion engine with that of Dr.

Rudolf Diesel. He admitted that "something less than justice was done to Akroyd-Stuart in his lifetime as a pioneer of the heavy oil engine," but added that since Diesel "laid down for the first time the essential features of the modern high economy engine," we must acknowledge him as "more than any other man its true originator." We have never failed to recognise the importance of the development effected by Dr. Diesel, but we submit that he has received more credit than he deserved—by the careless use of his name—and that even Mr. Pye himself has done a little bit less than justice to Akroyd-Stuart.

Far from altering the opinion we have several times expressed that the term "Diesel" should only be used in connection with air-injection engines, Mr. Pye's brief historical survey tends to confirm us in it. "The fact that a high-pressure blast has been used in many types of Diesel engines as a practical aid to fuel injection and distribution," he said, "has led to an idea that whereas injection with air is to be associated with the name of Diesel, airless injection is especially due to Akroyd-Stuart. This suggestion, however, is not founded upon facts. The use of high-pressure air was a device adopted as a practical expedient in the Diesel engine. There is no mention of it in the original patent, and there can be no doubt that Diesel originally conceived his engine as working with airless injection of the fuel." Whatever Diesel may have conceived is hardly to the point. It is equally possible that Akroyd-Stuart conceived injection by air blast. The fact is that all the engines constructed by Diesel and his licensees used the air blast, and thereby gave a particular character to the type. When in the course of time the miscalled semi-Diesel engine was introduced, it used a cycle that was nearer to that of Akroyd-Stuart than to that of Diesel. The compression ratio was lower, no air blast was employed, and ignition no longer depended upon the temperature of the pure compressed air alone, but largely upon the temperature of the cylinder walls. Akroyd-Stuart, it is true, used a "hot spot" of some kind to effect ignition, but as compression was increased by successive makers the absolute necessity for it vanished, and the result was an improved Akroyd-Stuart rather than a semi-Diesel engine. But whatever views may be held on this point, there is no doubt whatever that to the British inventor all the credit of pure-air compression belongs; in that he certainly anticipated the German doctor. Mr. Pye seeks to deprive him of some of the credit on the grounds that he did not use pure air as a fundamental feature of a thermo-dynamic cycle, but solely to prevent pre-ignition. On the same grounds we might rob a thousand inventors of credit because they did something without recognising the full significance of what they were doing. There is no question that Akroyd-Stuart used pure air because it was essential to his cycle; and that Diesel had to follow him when he took that cycle a stage further by going to a compression ratio far above that employed in the Hornsby-Akroyd engine. That is a fact, and to our mind it counts for more than theory when claims of priority are advanced. The Diesel cycle depends upon pure-air compression, and in that respect Akroyd-Stuart was first. Diesel aimed at, and achieved in a measure, constant pressure combustion, but apart from that fact, and a very high compression ratio, the two engines closely resembled each other save in the method of injecting the fuel. Akroyd-Stuart used solid or mechanical injection into a hot bulb; Diesel used a high-pressure air blast direct into the cylinder, and a distinctly characteristic feature of true Diesel engines is to this day the inclusion of an air compressor. Hence the practical high-pressure oil engine, as we know it now, owes as much to one inventor as it owes to the other, and to describe all such engines as "Diesel" does an injustice to a British inventor, and is terminologically inexact. "Akroyd-Diesel" would be a reasonable name—we suggest it to makers who think there is some magic in "Diesel"—but "Diesel" alone is not.

Mr. Pye's claim for Dr. Diesel as the "true originator" of the modern high economy oil engine is based on the academic—we use the adjective in no slighting sense—fact that he defined the principles of efficient internal combustion; in other words, that he had formed a clear scientific view of the object to be sought and the right means of seeking it. We do not wish for a single instant to underrate the credit which is due to him on that account. We would as soon think of robbing Joule, Kelvin, or Carnot of praise for their contributions to thermo-dynamics. But in the matter of invention the man who does something, even though he is unable to give a full scientific reason for doing it, or, furthermore, even if he secures success in one direction when he is looking for it in another, deserves recognition as a pioneer. Akroyd-Stuart had less scientific vision than Dr. Diesel; he did not see the full implication of pure-air compression; he probably did not even consider a very high compression ratio. But he very certainly did for the first time use compressed air instead of a compressed charge, and in his first engines injected fuel after compression had been completed. In these associated facts, which are the elements of all modern high-compression, heavy-oil engines, he anticipated Diesel.

Institution of Mechanical Engineers.

X-RAYS IN ENGINEERING PRACTICE.

FROM the articles previously published in our columns* our readers will already have gathered a good deal concerning the work which Dr. V. E. Pullin is carrying out in the Radiological Research Department at Woolwich Arsenal. As those articles indicated, radiology is applicable in two directions of engineering interest, namely, in the form of radiography and in the form of X-ray spectrum analysis.

That branch of the science known as radiography covers the exposure of the object to be examined to X-rays and the receipt of such of the rays as pass through it on a photographically sensitive film or paper placed behind the object, generally in immediate contact with its under surface. The proportion of the rays which pass through the body without being absorbed depends upon the density of the material composing the object and its thickness. If the body is of uniform density and thickness, the photographic film will be uniformly affected and on development will show a general "fog." If, however, the object contains portions of varying density or is of varying thickness, the film when developed will exhibit a shadowgraph of the portions which differ in density or thickness from the rest of the body. Hence the use of X-rays in Harley-street for the detection of broken bones or intestinal derangements. In the second named connection the requisite difference of density is induced in the parts to be examined by causing the patient some time in advance to drink a mixture of barium sulphate.

The degree to which bodies all of the same thickness are penetrated by X-rays depends strictly not on their density, but upon the atomic number of the elements composing them. The discovery of this fact by Moseley just before the war claimed him as one of its victims, has led to the modern system of classifying the elements according to their atomic numbers rather than by their atomic weights. Generally speaking, we may consider that the penetration of bodies by X-rays is determined by their density and may neglect this refinement concerning the atomic numbers of their elements. Hence it comes about that if a metal specimen or part contains an inclusion of slag or other foreign matter of density different from that of the metal, an X-ray shadow will be recorded on the sensitive film.

The degree of penetration is also determined by the thickness of the object. With the apparatus available a few years ago, half an inch of steel represented the greatest thickness of that metal which could be penetrated by X-rays. To-day the progress that has been made enables steel parts up to 5in. thick to be penetrated. As the thickness is increased up to that limit the amount of the penetration falls off. Herein and not because of any difference in density lies the reason why cracks in an otherwise homogeneous piece of metal are revealed by radiography. A ray cutting the crack has a definitely shorter length of the metal to penetrate than a ray which does not cross the crack. A shadow of the crack—more precisely, a shadow of the non-cracked portion of the specimen—is therefore cast upon the sensitive film. An internal cavity or gaseous inclusion in the body is visible under the X-ray partly because of the diminution which it causes in the length of path to be penetrated by the ray and partly because of the difference of density between the material of the body and the gaseous matter enclosed in the cavity. Radiography is therefore applicable to the determination in metal bodies of slag or other inclusions, cracks, and internal cavities. It is clearly also applicable for similar reasons to the determination of the correct assembly of finished parts without dismantling them. For example, it can be, and is, used to examine finished shell fuses in order to ascertain whether the safety pin has been duly included.

The second branch of radiology, X-ray spectrum analysis, takes us a considerable step beyond what we may respectfully call the Harley-street aspect of the science. It is based on the fact that the wave length of X-rays is of the same order of magnitude as the dimensions of atoms and molecules. By means of these rays it is, therefore, possible to probe into the structure of matter far beyond the limit at which the relatively gross waves of visible or even ultra-violet light cease to show anything beneath the microscope. X-ray spectrum analysis is applicable to a study of the structure of all materials possessing a crystalline character—and most bodies, even such typically "non-crystalline" substances as amorphous carbon and many colloids, are radiologically crystalline. The matter to be examined is presented to the rays, either as a crystal which is slowly revolved or as a fine powder. The rays reflected from the crystalline faces are caught and registered on a photographic plate and from the varied and frequently complex patterns of the image into which they group themselves, something concerning the molecular structure of the material under examination is sought to be deduced. In addition to Dr. Pullin's article on this subject which we published last July, the reader may like to refer to Sir William Bragg's Hawksley Lecture, "X-rays and the Crystalline Structure of Materials," an abridged reprint of which appeared in our issue of November 11th, 1927.

In his paper "X-rays in Engineering Practice," which he presented before the Institution of Mechanical Engineers last Friday, Dr. Pullin dealt with the radiographic aspect of the subject, and not with X-ray spectrum analysis. We reprint the paper substantially in full elsewhere in this issue. Dr. Pullin occupied about an hour in delivering his paper. We doubt if anyone in his audience would have grumbled if he had considerably exceeded that period, for he is not only a master of research, but a past-master of clear and delightful exposition. Like Professor Turner's address, a week previously, Dr. Pullin's was a lecture rather than an ordinary paper. Although a number of members spoke after the paper had been presented, it was with the object chiefly of asking questions and eliciting additional information. Of discussion in the usual sense, there was substantially none. It was noticed, not for the first time, that several of the questions were superfluous. When an author presents a summary of his paper, or, as Dr. Pullin did, expands it into a lecture which does not closely follow the text of the printed paper, it is very desirable that those who speak in the discussion should not rely solely on the author's spoken words, but should also read the paper beforehand. There is undoubtedly a growing tendency for people to speak on the strength of what they hear from the author's lips on the evening of the meeting. If a rule were instituted that no one should take part in the discussion who had not previously read the paper, the quality of the proceedings would be considerably improved. The volume of the discussion would, we are afraid, be at the same time very considerably reduced.

It seemed unnecessary for one speaker to ask Dr. Pullin to give some indication of the cost of operating a radiographic plant. The information required is to be found in the paper, although it was not included by the author in his verbal address. Neither was it necessary to ask the magnitude of the current consumed in X-ray tubes. It was stated in the paper that it rarely exceeds 10 milliampères for engineering work. It was superfluous for another speaker to ask if radiography were applicable to the detection of cracks and flaws in non-ferrous metals. The author's illustrations were drawn almost entirely, but not quite completely as the speaker implied, from its use on ferrous metals. The text of the paper made it quite clear that it is easier to radiograph aluminium than iron, and more difficult to radiograph brass, and that in general the less dense the metal the easier it is to deal with. It was almost, although perhaps not quite unnecessary for yet another speaker to ask whether X-rays would reveal the existence of inclusions of slag in the interior of metals. Dr. Pullin's illustrations, of which he showed many more on the screen than were included in the paper, laid perhaps principal stress on the use of radiography for the detection of cracks, blow-holes, and internal cavities. A study of the paper, however, leaves no room for doubt that an inclusion of slag or in general the existence within the metal of any portion differing materially in density from the rest of the specimen, will result in the casting of an X-ray shadow and will therefore be revealed by radiography. The same guiding principle supplied the answer to the question put by another speaker, who asked whether X-rays would reveal the depth of hardening in a case-hardened body, or whether a body was case-hardened or not. Since the case is of the same or almost exactly the same density as the core of the body, it is self-evident that X-rays will not reveal either its existence or its depth.

A slight misunderstanding of the lecturer's spoken words prompted another speaker to express a certain element of hostility to the use of radiography in engineering. The author, he contended, had indicated that for the successful operation of a radiographic plant super experts were required, and that of two men who were merely experts, one might report a defect where the other would find none. Basing his argument on this impression of what the author had intended to convey, the speaker expressed a discouraging view concerning the economic practicability of applying X-ray examination under commercial conditions. He would rather, he said, expend the money on the development of means for avoiding the existence of cracks and blow-holes in steel than on methods for detecting their presence. The point

* "X-rays in Engineering," THE ENGINEER, February 21st, 1930; and "X-ray Crystal Analysis in Engineering," THE ENGINEER, July 4th, 1930.

may not have been made quite clearly in the printed text, or in Dr. Pullin's spoken address. The real contention is that the *design* of the apparatus should for reasons of efficiency and health always be entrusted to a highly skilled specialist. The *operator*, however, need not be a super expert, or, apparently, even a mere expert. In his paper, and on the screen, Dr. Pullin illustrated an equipment designed for the routine examination of fuses in order to detect after assembly the omission of any vital detail. The design of this apparatus was the work of an expert, but its operation, it was specifically stated, was in the hands of unskilled people who had been trained with little difficulty in the necessary technique.

Mr. Gresley was the only speaker who asked questions that elicited from the author replies which materially enlarged the information he had already given. But even he was to a certain extent guilty of superfluity when he asked Dr. Pullin if X-rays could be used to reveal hidden flaws in railway axles, 7in. or 8in. in diameter. It had been made clear in the author's address that with present equipment 5in. is the maximum thickness of steel that can be penetrated by the rays. In the paper it is explicitly stated that with a voltage of 300,000, some 6in. of steel might be penetrated, but that so far it had not been practically achieved. There is, therefore, no hope for the present of examining axles 7in. or 8in. in diameter. Mr. Gresley, however, also raised the question of examining railway tires radiographically, and inquired whether it would be possible to do so by mounting the tires in such a way that they could be slowly rotated during the exposure in order to obtain a complete and continuous record of their character. The question was of importance in itself, and also because it drew from the author a definite statement regarding the length of exposure required in taking a radiographic record, a point concerning which the address and the paper were silent or ambiguous. Obviously, if the exposure is a question of hours, Mr. Gresley's suggestion for obtaining a continuous record by the slow rotation of the tire would, as he himself recognised, be of no avail. Dr. Pullin assured him that the exposure required would be a matter of minutes. The suggestion was, he said, practicable, although to carry it out would involve the use of a specially designed X-ray tube and a very high voltage. There was, he added, no difficulty in examining railway tires radiographically with a step-by-step exposure. Some few years ago he had successfully examined a tire 4in. thick, which had been involved in a railway accident.

Mr. A. E. L. Chorlton was in the chair at the meeting, in the absence of the President through indisposition.

Literature.

Coke for Blast-furnaces. By R. A. MOTT and R. V. WHEELER. Pp. xxiv, 267, demy 8vo. London: The Colliery Guardian Company, Ltd. Price 25s. net.

THIS book is described as Report No. 1 of the Iron and Steel Industrial Research Council, and, alternatively, as the first report of the Midland Coke Research Committee. After a brief introduction dealing with general principles and enumerating the objects comprised in the programme to which the Committee had addressed itself in undertaking the task, the main body of the book is divided into two portions, Part I. dealing with the specification of blast-furnace coke, and Part II. with the manufacture of blast-furnace coke to specification. Part I. has chapters on the qualities to be specified, such as coke size, structure, analysis, density and porosity, abradability, hardness, the rather complex and controversial question of "reactivity," and finally summarises the various considerations in a chapter entitled "The Specification of Coke." This turns out to be quite inconclusive. The most the authors feel they can discuss in this connection are "the lines on which specifications for coke could now be drawn." All that emerges is that a single rigid specification is of limited value, a conclusion that might be foreseen, and the suggestion of a specification in which a value would be placed on each of the more important properties of coke and a sliding-scale basis of payment adopted, with bonus and penalty clauses. This is a suggestion which, apart from the innumerable disputes it would inevitably involve, is hardly likely to appeal either to coke makers or to blast-furnace managers. To pay on a see-saw balance of compromises by which a thoroughly bad property could be cancelled out by two or three good ones would satisfy no one, and could hardly afford a basis for any specification likely to be of use. After all, whether, in the blast-furnace, a coke behaves well or ill, is just as much the result of specific conditions peculiar to the particular plant, as of any but the very broadest, and in particular instances unspecifiable intrinsic properties of a coke considered *qua* coke and apart from its behaviour with special, and varying, ore burdens. There would have to be as many "specifications" as there are kinds of ore, chemical and physical, and, probably, kinds of furnace as well—height, cubical capacity, &c. Until blast-furnace practice is standardised, which is an impossible condition, the best that can be hoped for is a wide range of cokes suited to the equally wide range of requirements in totally different conditions in different districts.

This is not to say, of course, that there are not a few, a very few, "constants" of quality ascertainable, and very widely, although not universally, applicable. For the investigation of such basal properties the authors are amongst the best qualified in the country, and their work, as embodied in the present volume, is deserving of the highest praise. Size, hardness, abradability, density, porosity, moisture, ash, sulphur, and even phosphorus content, are properties which every blast-furnace man must take into the closest account in connection with the working of his particular furnace or furnaces, and the more information forthcoming in those respects, and the better their interconnection is understood, the closer, and more economic will be the adjustments he will be enabled to make. In supplying so much of what it is highly desirable to know, the authors have rendered, most conscientiously, a very valuable service to the blast-furnace industry, and their book is one which should have a wide circulation amongst all concerned in the particular aspects of the "fuel problem" with which it deals.

Part II. deals with the conditions, in coke manufacture, which influence its properties. Seeing that, in Part I., the authors have practically conceded the principle that coke specifications are not at present practical propositions, unless weighted with a number of "ifs" and "buts," the title of this part of the book is misleading, for it can hardly be said to deal with "The Manufacture of Blast-furnace Coke to Specification." On the other hand, it does deal, and very excellently, with the manufacture of coke, its scope being indicated by an enumeration of its chapters. These deal with the influence of the character of the coal, with blending, with the effect of the size of the coal on the product, with that of the method of charging, with that of moisture, or rate of heating the oven and of quenching, screening and handling the coke, a chapter being devoted to each of these considerations, with a final chapter on methods of research on blast-furnace coke. There is given, as an appendix, an exhaustive table of tests on an exceedingly wide range of cokes, running into eighteen closely printed pages.

In conclusion, we might suggest, not by any means in criticism of the present volume, which is a capital contribution to the literature of blast-furnace coke, but rather by way of influencing, if possible, the nature of future researches to be undertaken by the parent research body, or by the authors themselves, that the problem of blast-furnace coke manufacture is best tackled by studying the blast-furnace end first. This is the end mostly approached by American investigators, in connection with which the work of Furnas and Joseph and of other investigators may be cited. Before anything like hard-and-fast views of what properties are desirable in a blast-furnace coke, and should therefore influence its selection, can be laid down, we want to know a great deal more than we do about what is going on inside the furnace. Even a particular furnace can, by due adjustments in the burden, in the rate of drive, and in numerous other ways, be made to give all kinds of results with the same coke, or even within reasonable limits the same results with all kinds of different cokes. Specifications for coke would have to be drawn up with a view to meeting such varying conditions, and to start on the assumption that the problem can be solved from the coke end seems rather like putting the cart before the horse. However, the authors of "Coke for Blast-furnaces" have written a very good book, which certainly comprises more than any other book on the subject of blast-furnace coke, and for this the industry, as we have previously implied, should be thoroughly grateful to them.

BOOKS RECEIVED.

The Portrait of Peter Pett and the Sovereign of the Seas. Newport, Isle of Wight: Yelf Brothers, Ltd., Holyrood-street.

British Rainfall, 1929. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C. 2. Price 15s. net.

The Manufacturing Industries of the British Empire Overseas. Part I., Canada. London: Erlangers, Ltd., 4, Moorgate, E.C. 2.

Untersuchungen über den Luftwiderstand. By Dr.-Ing. Karl Sutter. Munich: R. Oldenbourg, Gluckstrasse 8. Price 6 marks net.

Whitaker's Almanack, 1931. By J. Whitaker, F.S.A. London: J. Whitaker and Sons, Ltd., 12, Warwick-lane, E.C. 4. Price 6s. net.

Heat Treatment in Forging Steel. By B. Saunders, London: Crosby Lockwood and Son, Stationers' Hall-court, E.C. Price 5s. net.

Calvert's Mechanics' Almanack, 1931. Edited by J. Brooks. London: John Heywood, Ltd., 20–22, St. Bride-street, E.C. 4. Price 6d. net.

The Modern Steam Turbine. By Dr.-Ing. E. A. Kraft. Berlin: V.D.I. Verlag G.m.b.H., Dorotheenstrasse 40, N.W. 7. Price 5·80 marks net.

Proceedings of the Staffordshire Iron and Steel Institute, 1929–30. Birmingham: The Staffordshire Iron and Steel Institute, 26, Galton-road, Warley.

Afrikaans Self-taught. By L. W. Van Os, edited by H. J. L. Van Os. London: E. Marlborough and Co., Ltd., 51, Old Bailey, E.C. 4. Price 3s. net.

Der Einkauf in der Metallindustrie. By Dr.-Ing. Berthold Buxbaum. Berlin: V.D.I. Verlag G.m.b.H., Dorotheenstrasse 40, N.W. 7. Price 12·50 marks.

Zweiundzwanzigste Berichtfolge des Kohlenstaubausschusses des Reichskohlenrates. Berlin: V.D.I. Verlag G.m.b.H., Dorotheenstrasse 40, N.W. 7. Price 1·50 marks net.

Concrete Joints in Concrete: Bonding New Concrete to Old. By Norman Davey, B.Sc. London: His Majesty's Stationery Office, Adastral House, Kingway, W.C. 2. Price 2s. net.

Garcke's Manual of Electrical Undertakings and Directory of Officials, 1931. Edited by F. C. Garrett. London: The Electrical Press, Ltd., 13–16, Fisher-street, W.C. 1. Price 35s. net.

Berichte des Ausschusses für Versuche im Stahlbau. Part IV.: Versuche zur Ermittlung der Knickspannungen für versichiedene Baustähle. By W. Rein. Berlin: Julius Springer.

The Insulation and Fittings of Refrigerated Spaces on Shipboard. By R. M. Buchanan. London: The Draughtsman Publishing Company, Ltd., 96, St. George's-square, S.W. 1. Price 2s. net.

Specifications in Detail. By F. W. Macey. Fourth edition, revised by D. Brooke, M.A., &c., and J. W. Summerfield, P.A.S.I., &c. London: Crosby Lockwood and Son, Ltd., Stationers' Hall-court, E.C. 4. Price 36s. net.

Sailing Ships: Their History and Development as Illustrated by the Collection of Ship Models in the Science Museum. Part I., Historical Notes. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C. 2. Price 3s. net.

Berichte über betriebswissenschaftliche Arbeiten. Vol. 5. Abnutzung von Metallen unter besonderer Berücksichtigung der Messflächen von Lehren. By Dr.-Ing. O. Nieberding. Berlin: V.D.I. Verlag, G.m.b.H., Dorotheenstrasse 40, N.W. 7. Price 6 marks net.

SIXTY YEARS AGO.

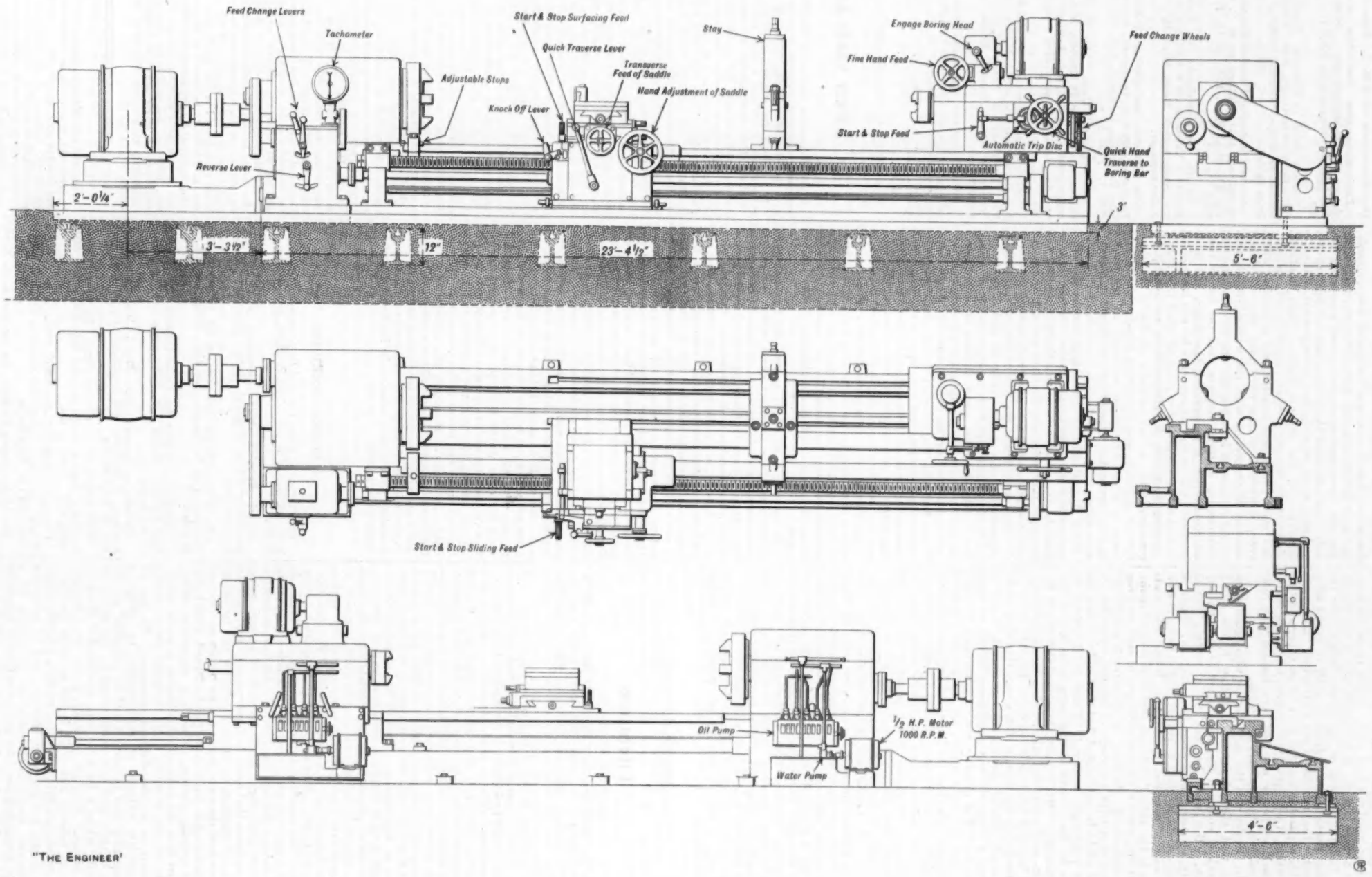
A CONSIDERABLE amount of miscellaneous information possessing historical interest is to be obtained from our issue of December 23rd, 1870. Macquorn Rankine, a highly valued and frequent contributor to our columns at that time, concluded a short series of articles entitled "On the Explosive Energy of Heated Liquids." The professor's object was not to discuss one of the factors in the explosion of boilers, but the sudden evaporation of highly heated water as a means of propelling projectiles. The "steam gun," as it was called, had first been invented by Perkins. Interest in it had recently been revived by Sir Henry Bessemer. We severely criticised Sir Henry's ideas and a somewhat acrimonious discussion had ensued. Macquorn Rankine, in his articles, presented a mathematical treatment of the subject. His results supported our criticism of the proposal. An effective steam gun, he showed, would require a very high boiler pressure—in one case he put it at 11,770 lb. per square inch—and for efficiency and safety would need a very long gun barrel, so long that it would probably, for convenience, have to be made in the form of a coil. A brief note elsewhere in the same issue recorded that Monsieur (*sic.*) Krupp was manufacturing twenty of his cannons for the destruction of balloons. The aeronautical successes of the French besieged in Paris had proved very galling to the Prussians. To interrupt the regularity with which the balloon post was operating, Krupp undertook the work of producing what may well be considered the first anti-aircraft gun. A curious sidelight on the conditions prevailing at that time in the British Navy is revealed in another paragraph. The "Hercules," the finest ironclad in the Fleet, had, we recorded, had a narrow escape the previous week. While a sentry was hanging up a lamp, the ship lurched and the naked light was thrown on to some powder cases. An officer, fortunately, was close at hand. Rushing across the deck he quickly extinguished the candle and thereby, probably, saved the ship and many lives. The Franco-Prussian war was dragging on to its tragic conclusion. So far, this country had succeeded in avoiding being drawn into the conflict, but it was evidently felt that the danger was far from over. We reported that a careful scheme for the defence of London had been prepared. Points of importance had been selected, at which, when the necessity arose, earthworks would be rapidly erected and armed after the manner which had been followed by the Russians in the defence of Sebastopol and copied effectively by the French defenders of Paris. From the reports of our trade correspondents, the same impression is gathered of the anticipation of war. Much of the activity being experienced in the production of munitions of war was, no doubt, to be traced to the demands made on our manufacturers by the actual combatants on the Continent and their apprehensive neighbours. Our own Government was, however, responsible for much of the work, for it was doing all in its power to bring the Navy and Army rapidly up to a much improved state of readiness for action.

THE bridge-building programme of the Quebec Provincial Government, shortly to be submitted to the Legislature, will involve an expenditure of between 15,000,000 and 20,000,000 dollars. It is proposed that at least three bridges shall be built on the south shore of the St. Lawrence, of which one is on the Richelieu River near Sorel and one on the Yamaska River at St. François du Lac. It is also understood that the Government will buy the Belliar and the Bellefeuille bridges on the north shore and rebuild them in order to improve the highway. A bridge between Caughnawaga and Ville Lasalle is included in the programme.

SUPER HIGH-SPEED LATHE

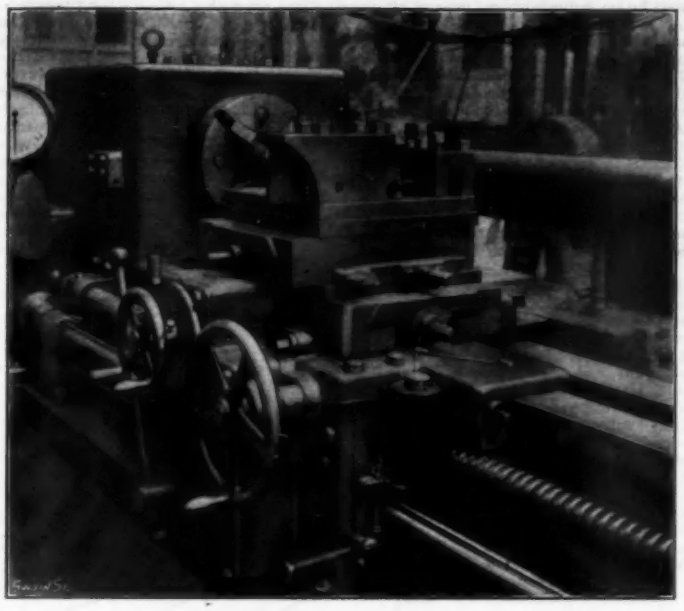
JOHN HOLROYD AND CO., LTD., MILNROW, ENGINEERS

(For description see opposite page.)

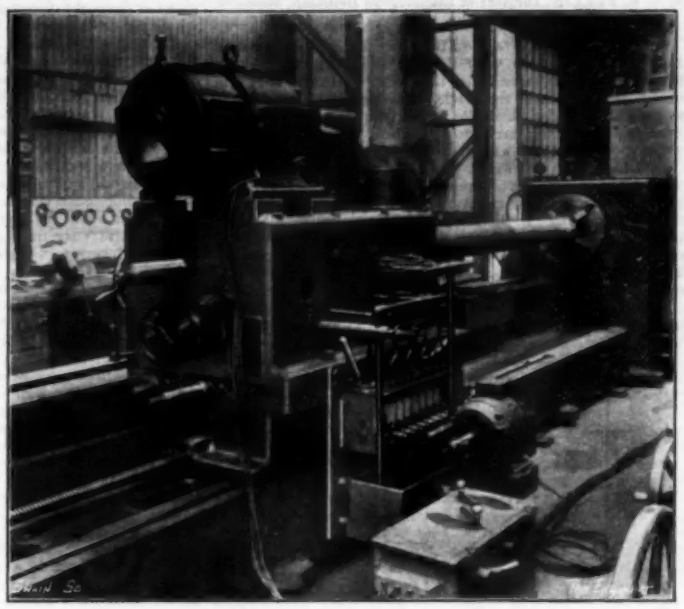


"THE ENGINEER"

SUPER HIGH-SPEED LATHE



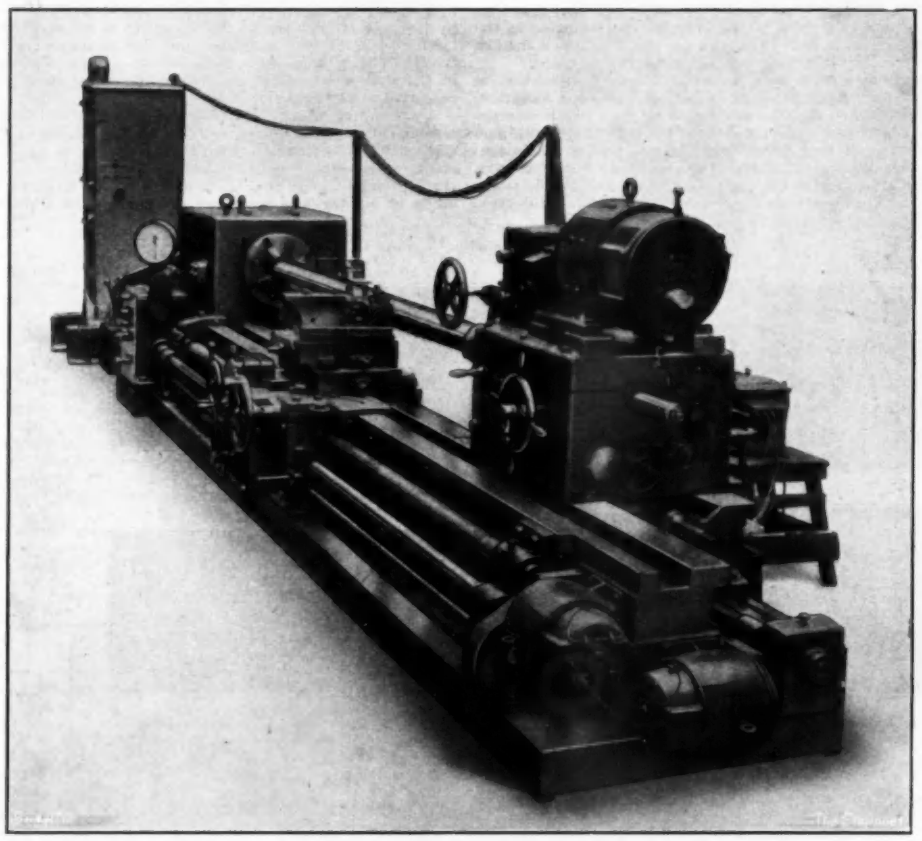
SADDLE AND SLIDE



REAR VIEW SHOWING LUBRICATION SYSTEM

Super High-speed Lathe.

AN interesting lathe, which was recently designed and constructed by John Holroyd and Co., Ltd., Milnrow, near Rochdale, to take full advantage of the most modern cutting tool materials, such as tungsten-carbide, &c., is illustrated herewith. In the design of this lathe several new features are embodied. It is electrically driven and controlled on the Ward-Leonard system, the main 45 horse-power variable-speed motor being directly coupled to the spindle through one pair of double helical oil-sprayed gear wheels in the headstock. The lathe is extremely rigid, and the tool cuts "upside down" similarly to a back tool which makes for steady and smooth cutting, and delivers the turnings downwards to the rear. It will be seen that the work is carried in chucks bolted direct to the flanges of the fast and loose headstock spindles, both of which revolve in "Holfos" bronze capped bearings, lubricated by cooled oil under pressure. The loose headstock spindle is driven by the rotation of the object which is being turned. The makers claim that it is impossible to do heavy cutting with the work revolving between dead centres, as in an ordinary lathe, but by gripping the work in a chuck and revolving the loose head spindle a solution of this problem has been achieved.



GENERAL VIEW OF THE LATHE

The design of the bed and saddle is such as to provide resistance to torsion and thrust, while facilitating the removal of the cuttings. With this object the bed is built of box section in triple step formation. It comprises a main gantry running the full length into the seating for the fast headstock and a front and a rear step. The latter carries a short auxiliary bed to support the back surface of the loose head stock, the front surface of which is supported and guided on the main gantry. The saddle is carried and guided on the main gantry and the front step. It is adjusted to these faces by means of taper strips and is supported without any overhang.

The saddle and slides comprise a square turret and swivel slide, provided with hand feed mechanism for turning short tapers, and there are longitudinal and cross feeds for sliding and surfacing or cutting off purposes, while there is a quick power traverse along the bed by means of a separate reversing electric motor controlled by a push button. The square turret and swivel slide have large circular dove-tail wedges, and the cross and inward slides have taper strips, so that they can all be firmly clamped to make one solid unit which is free from vibration, the only moving slide being that which is actually concerned in the operation. A one-shot central oiling system, such as is popular in motor car lubrication, is applied to the saddle and slides.

The loose head is adjustable by means of a screw on the auxiliary bed, which is moveable along the rear step of the main bed by a separate reversing motor. To form a chute for the cuttings the rear step is covered by inclined steel plates between the auxiliary bed and the fast headstock. The spindle of the loose head has a chuck bolted to its flange, and an inner sliding spindle which can be fitted with a centre if required. Further, if desired, the loose headstock can also be arranged as a boring head, with a separate motor drive and variable automatic feeds, for such purposes as boring out the ends of shafts, &c., while supported by a stay. With this method the boring spindle revolves in the opposite direction to that in which the work is being slowly rotated, thus obtaining higher cutting speeds without revolving the work at high speed in the stay.

The following are the leading particulars of the lathe :—

Maximum diameter of work (turning)	20in.
Maximum diameter of work (cutting off)	14in.
Maximum length	11ft.
Height of centres	15in.
Main drive motor	45 B.H.P.
Spindle speeds	6·66 to 400 r.p.m.
Sliding feeds (six changes)	$^1/_{7}$in. to $^1/_{42}$in. per rev.
Surfacing feeds (six changes)	$^1/_{14}$in. to $^1/_{84}$in. per rev.
Quick traverse speed of saddle	18ft. per minute
Power of quick traverse motors	3 B.H.P.
Length of bed	23ft.
Floor space	34ft. 6in. by 6ft.

If the loose head is also arranged for boring purposes, the power of the driving motor is 7½ B.H.P., and the boring spindle speeds are 100 to 300 r.p.m., while the feeds vary between $^1/_{10}$in. and $^1/_{100}$in. per revolution.

AUTOMATIC LIFT OPERATION.

IN a modern tall office building with 25 to 45 floors and a dense population with continual movements, it is important to move the lifts swiftly when running and to reduce delays at landing to a minimum. The New York News Building, with 36 floors, has thirteen passenger lifts, a service lift and two goods lifts, sixteen in all, of which only the goods lifts are without automatic control. Three of the cars run from the first to the ninth floor at 600ft. per minute; five at 700ft. run to the 23rd floor, but stop only at those above the ninth, while five at the same speed run to the top of the building, but make their first stop at the 23rd floor. As passengers enter they call the numbers of the floors they want and the attendant presses buttons of corresponding numbers. On getting the signal to start he shifts a lever causing the power-operated doors to close and the car to start automatically. At each successive floor for which a button has been pressed the car slows and stops level with the landing, the doors then opening automatically. When the passengers have got on or off the car, the attendant again shifts his lever, the doors close and the car resumes its journey. A passenger on an upper floor wishing to ascend or descend, presses a corresponding button and the next car coming up or down, respectively, will stop automatically. At the top landing, the control system is automatically reversed for the down trip. Cars cannot be run on fixed schedules, as one car coming down may be signalled and stopped at several floors, so that the next car will gain on it. To take care of this condition, indicators in the car dispatcher's office show both the position of each car and the floors for which it is signalled. If a car making many stops is loosing time, the dispatcher can switch the signals so that they are cancelled in that car and are by-passed to the next following car. Special equipment in the car enables the attendant to stop it or reverse its movement in case of necessity.

ACCORDING to the *Iron Age*, a deposit of iron ore amounting to some 275 million tons, on the eastern slopes of the Ural Mountains, is to be exploited by the Russian Government. Blast-furnaces, Bessemer and open-hearth furnaces are to be installed to make about one and a-half million tons of steel a year.

X-Rays in Engineering Practice.*

By V. E. PULLIN, Director of Radiological Research, Research Department, Woolwich.

IT is the author's intention to show in the present paper that radiology has a very definite place in engineering practice. At the same time, it is very desirable that the limits of usefulness of the method as a practical test should be carefully defined, because in many quarters wrong impressions exist, and serve to limit and ultimately to discredit the subject as a whole.

In describing the exact position of radiology in the present state of its development, it is hoped that members' specialised knowledge will enable them to assess its present value and its potentialities. As far as possible, all technicalities concerned with the practice of radiology will be avoided, for they only concern the specialist, and may easily confuse the subject from the point of view of determining its possible application in practical engineering.

The application of radiology to engineering may be divided generally into two parts—(1) the examination of

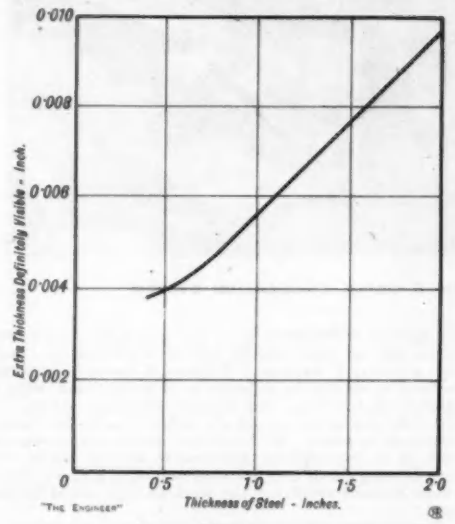


FIG. 1

Minimum change of thickness of Steel definitely discernible with 200 kv. radiation under good conditions.

castings, forgings, and so on by radiography to show flaws and lack of homogeneity in the structure; and (2) the X-ray spectroscopic investigation of metals to determine the fine structure and the modifications it undergoes as a result of common engineering processes. The second of these applications involves a certain amount of theoretical treatment, and the paper will be confined to radiography, as it is the author's desire to present the subject broadly and unhampered by technical detail.

An X-ray tube may be likened to a lamp, for X-rays are, indeed, a form of light differing from visible light only in having a wave length some ten thousand times shorter. They have many of the properties, however, of ordinary light, one of the most important being that they affect a photographic plate in exactly the same way, but they differ from it in that they can penetrate opaque bodies. X-rays are produced artificially by passing a high-tension discharge through an evacuated envelope containing positive and negative electrodes.

The necessary equipment therefore consists of an X-ray tube, a high-potential generator—usually an oil-immersed high-tension transformer with its accessory apparatus—and a suitable stand or holder for the tube. It is generally known that X-rays, particularly high-power X-rays, are dangerous to the health of those employed in their vicinity, and somewhat elaborate precautions are therefore observed to prevent their escape except in the direction required. It is largely for this reason that the design of X-ray equipment is important, particularly for industrial work where the rays are in constant use. Design of X-ray equipment should always be in the hands of a specialist, and governed by the special requirements of the case. If the equipment is properly designed, there need be no apprehension whatever on the ground of danger.

All materials absorb X-rays, and, generally speaking, the denser the material the more difficult it is to penetrate. Thus iron is more difficult than aluminium, brass is more difficult than iron, and lead very difficult indeed. On the other hand, the penetrating power of the rays depends upon the voltage at which they are generated; whereas 40,000 volts would enable us to penetrate 4in. of aluminium, it requires some 250,000 volts to penetrate 4in. of steel. Therefore any equipment designed to examine heavy engineering materials must necessarily involve extremely high voltages. At the same time, the power is low, because the current consumption in an X-ray tube is very small, rarely exceeding 10 milliampères for engineering work.

The absorption of X-rays in materials and its corollary, X-ray penetration, is so important from the engineering point of view that a little attention must be devoted to its consideration so that a clear conception of the various factors involved may be obtained. In the first place, an X-ray beam consists of many different wave lengths. According to the impressed voltage, this band of wave lengths has a definite limit on the short-wave side; that is to say, it has a maximum penetrative value at any given voltage. If we allow such a beam of X-rays to fall upon and penetrate a solid piece of steel, it undergoes certain modifications in the course of its transmission. Part of the beam, composed principally of the shortest of the waves, passes right through the material and emerges on the other side. Part of the beam in encountering the atoms of the metal, suffers a change in character; this part, we say, is truly absorbed. Another part is deflected hither and thither in the material, and is scattered exactly as visible light is scattered by fog. Some of this scattered radiation is, in turn, truly absorbed, and some of it emerges in all directions from the surfaces of the transmitting medium. We shall see that this component plays a very important part in practical radiography. The absorption of X-rays by a homogeneous material may be expressed by the familiar exponential equation $I_E = I_0 e^{-\mu d}$, where e is the base of Naperian logarithms ($e = 2{\cdot}72$), μ is the coefficient of absorption of the material, and d its thickness. The coefficient μ is really the sum of two separate factors, the absorption due to scattering and the true absorption.

Most people know that X-ray pictures or radiographs are really shadowgraphs. An X-ray picture produces no graphic representation, but merely a series of varying densities or shadows due to the differential absorption suffered by the rays in their path through the specimen. If we pass our rays through a perfectly homogeneous medium the photographic emulsion will all be affected to the same extent, and the result will be a perfectly uniform appearance. On the other hand, if there is a hole in the specimen, there will be less X-ray absorption at that place, and there will be a corresponding variation in the emergent beam of X-rays, and the result will be a shadow of *increased* blackening on the photographic plate.

Before we pass on to consider X-ray examination in detail, reference will again be made to scattered radiation. In addition to the incident beam, part of which emerges unchanged and undeviated from the side of the specimen remote from the X-ray tube, and is really the image-forming component of the beam, we have scattered rays, which emerge from the surface at every conceivable angle. In *quantity* these rays very much exceed the useful rays. They, too, are X-rays of comparable penetrating power to the primary beam, and they, too, affect the emulsion of the photographic plate. They produce a general fogging, which may do much to reduce contrast, and thus spoil the radiograph. It may be shown, too, that as we deal with thicker metal specimens, and consequently are compelled to use more penetrating radiation, the amount of scattered radiation increases. Thus, unless we can limit its effects, there is a possibility that the fog produced by scatter may ultimately destroy all useful contrast. There are several ways of dealing with the matter; we may interpose a thin metallic screen between the specimen and the plate, and so absorb a large amount of scatter, or we may use a special piece of apparatus called a Potter Bucky grid, which is so arranged that only the direct X-rays are allowed to pass, the other rays being cut off and absorbed by suitably placed absorbing slats.

The important principle to observe is that all radiation other than the main incident beam should be prevented, as far as is possible, from reaching the photographic emulsion. Lead, being a highly absorbing material, is usually employed when we wish to inhibit the passage o X-rays, whether for reasons of health or technique. In practice, it is usual to cover the specimen as completely as possible in metallic lead, with the exception of the actual area under examination. Sometimes, however, such perfect screening is not possible, and the closest practical approximation to it is employed.

A small experiment will suffice to show the magnitude of the phenomenon of scattered rays. A beam of X-rays is allowed to penetrate a slab of steel. In one part the rays, after penetrating the steel, are made to pass through a small hole in a lead cylinder, and all the scattered rays are thus absorbed by the walls. Consequently, only the undeviated primary beam is allowed to reach the photographic plate. In another part of the experiment, the

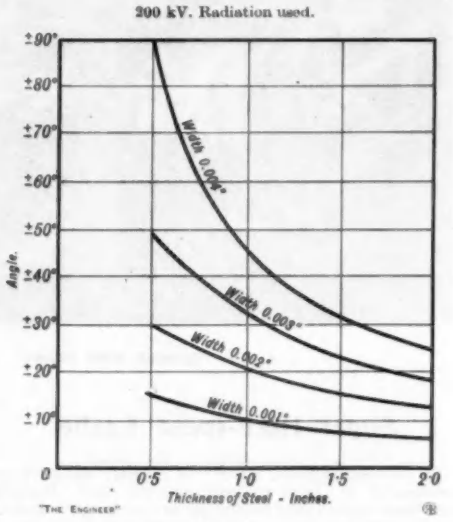


FIG. 2

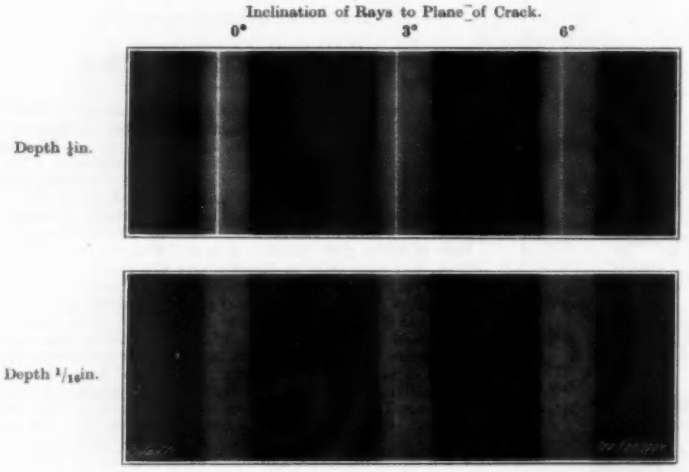
Angles through which Cracks of various widths are visible in Steel under good conditions.

rays penetrate the steel, and directly affect the emulsion. Here the scattered rays from the under surface of the steel also add their quota to the reduction of the emulsion. A round hole is the photographic effect due to the primary beam alone after penetrating the steel, the exposure being four units. Three different areas of density are produced by the primary beam plus the scatter from the specimen, having had one, two, and three units of exposure respectively. The density of the round spot is the same as that of the first area. Thus the scatter has three times the intensity of the primary beam alone.

Another experiment illustrates the way in which the scatter persists and affects the film at comparatively large angles from the main beam of rays. Here, again, the emergent rays from the specimen are restricted by passing through small holes in a thick lead screen. Even at an angle of 60 deg. the scattered rays have still a photographic effect. The fog-producing effect of scatter is therefore both considerable and troublesome.

Technique is thus very important if good and reliable radiographs are to be obtained. There is, in fact, a danger that this valuable method of inspection may often be discredited, owing to unskilful operators. It is to be hoped that as radiographic inspection becomes more generally known, facilities for training operators will become available in this country, as they are now in Germany and America.

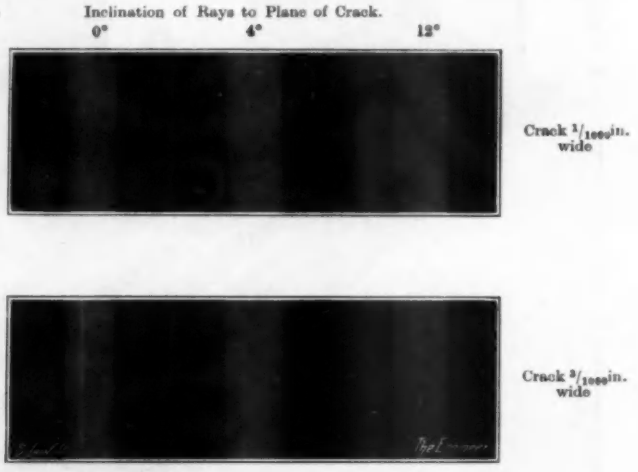
Engineers often ask whether X-rays may be employed to detect hair-line cracks, "ghost" lines, "rokes," and so on. This is a practical question of great importance. With regard to ghost lines and rokes, these two conditions do not occasion any appreciable change in density of the material, and, therefore, they do not produce an X-ray shadow. The question of the detection of cracks, on the



NOTE.—In the case of deep cracks the appearance depends considerably upon the obliquity; but in the case of shallow cracks the change of appearance with obliquity is small.

FIG. 3

Cracks 3/1000in. wide in Steel 1in. thick.



NOTE.—A crack is seen through an angle approximately proportional to its width. A 1 mm. crack at 4° and a 3 mm. crack at 12° are equally discernible.

FIG. 4

Cracks ¼in. deep in Steel 1in. thick.

* The Institution of Mechanical Engineers. Abstract.

other hand, is entirely a relative one. Let us consider cracks under three headings: (1) Those with no appreciable depth and no appreciable thickness—these would probably be called hair-line cracks; (2) those which have appreciable depth, but are vrey fine indeed—these also may be called hair-line cracks; and (3) those which have appreciable depth and appreciable width.

In order to study the radiographic significance of fine cracks, a specimen had to be artificially constructed so that a crack of known dimensions could be placed with its plane at a known angle to the X-ray beam in a definite thickness of metal. The metal chosen was 1in. of mild steel; the crack was formed by cutting a rod of steel longitudinally and screwing the smooth faces together

FIG. 5

Cracks in Steel 1in. thick.

NOTE.—In the case of shallow cracks the appearance is determined more or less by the volume and not simply by the depth.

with a predetermined amount of space separating them. The depth of the crack was governed by the diameter of the steel rod. The desired angle was obtained by twisting the rod.

Fine cracks are the most difficult flaws to determine radiographically. They occur as a radiological problem chiefly in forgings and are usually visible on the surface. It is often desirable to ascertain their depth.

If a fine crack is directly in the plane of the rays it is comparatively easy to show it, but it remains to define the maximum angle to the plane of the rays that still allows the crack to show. The question of the depth or shallowness of a crack is relatively unimportant from this point of view. We find, as we should expect, that the deeper the crack the broader the band of shadow on the radiograph. On the other hand, the width of the crack and its angle to the plane of the incident radiation are the determining factors in the relative brightness of the radiographic image, which is the really important factor.

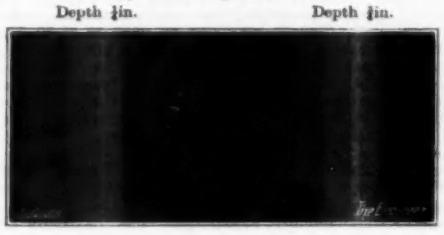


FIG. 6

Cracks 3/1000in. wide in Steel 1in. thick.

NOTE.—At a moderate angle the discernibility of a crack is determined almost entirely by its width; the depth has little effect.

If a crack of width t is at an angle θ it reduces the effective thickness of the metal to be penetrated by an amount t cosec θ.

Fig. 1 shows how the ability to see a crack is determined by the amount of the reduction in thickness caused by the crack in the direction of the rays. The visibility depends upon angular displacement for cracks of various widths in increasing thickness of metal.

Fig. 2 is of interest in that it shows the importance of the width of a crack in producing contrast in a radiograph. Comparisons have been made of cracks varying from 1/1000in. in width to 5/1000in., and in depth from 1/8in. to 1/4in. In general the result is that for shallow cracks visibility depends upon the total area of the crack. The minimum area that can be detected radiographically is 1/10000 square inch in 1in. of steel. This approximates to a crack 1/8in. deep and 1/1000in. in width, or, of course, to a crack 1/32in. deep and 2/1000in. wide.

Fig. 3 is a comparison of a deep and a shallow crack inclined at angles of 0 deg., 3 deg. and 6 deg., to the plane of the rays. In the deep crack it will be seen that the radiographic appearance depends upon the obliquity; but in shallow cracks the change of appearance is apparently small. Fig. 5 compares a shallow wide crack and a deep narrow crack. The radiographic appearance is much the same, indicating that this is determined largely

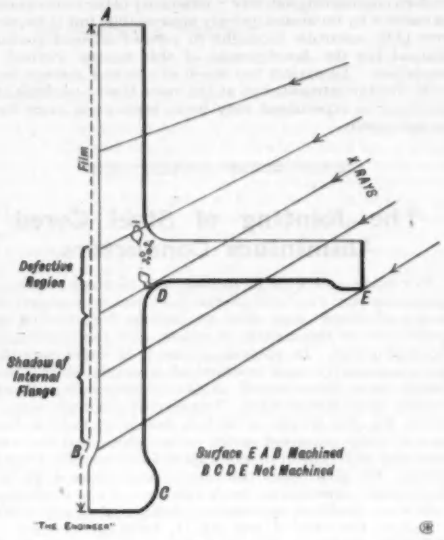


FIG. 8

Illustrating method of Radiological examination.

by the area and not simply by the depth. Fig. 6 compares a deep and a shallow crack inclined at an angle of 5 deg. to the plane of the rays. The radiographic density in this case is much the same, the appearance depending upon the width of the crack. Fig. 4 compares a narrow and a wide crack of the same depth at various angles to the plane of the rays and illustrates the fact that a crack is seen through an angle approximately proportional to its width.

It follows from these experiments that very fine cracks, even as fine as to warrant the appellation "hair-cracks," may be discernible by X-rays, and further that the fundamental factor governing their visibility is their width. It will be appreciated that the appearance of the radiograph affords some sort of a guide as to the depth of a crack; but such an estimate is not reliable. If, however, a crack has really appreciable width and depth, stereoscopic technique will yield the required information. This will be referred to again when some practical problems are considered. It will be observed that the experiments described depend for their significance upon the contrasts that are discernible on a photographic film. Indeed, the factor that is of primary importance in all radiographic work is contrast in intensity. We may sum up these experiments with artificial cracks by saying that in general a shallow crack presents the radiographic appearance of a line, whereas a deep crack of appreciable width—say, 1/1000in.—presents the appearance of a band. On the other hand, both a deep narrow crack and a comparatively wide shallow crack present a line appearance, which goes to show that from the point of view of photographic contrast it is the total area that avails to produce an image when radiographing fine cracks. While it certainly is possible to show cracks of less than 1/1000in. wide radiographically their appearance on the film depends upon the conditions being particularly favourable, and, consequently, their detection should not be relied upon in practical work.

The general purpose underlying these experiments with artificial cracks was to define the practical limits of fine radiography, and the results obtained go some way towards the desired end. At the same time, there is a great deal more to be done experimentally in the investigation of irregular isolated cracks and cavities of small dimensions.

The next question of practical importance is concerned with the interpretation of radiographs in mechanical engineering terms. A radiograph of a casting or a forging will exhibit a variety of gradations of shade and possibly white patches of irregular shape. What do the marks mean? And how far do they go in enabling the engineer to reject or accept the specimen? The first procedure should be to compare the radiograph with the corresponding area on the specimen, and if the surface is irregular, as it probably will be, it may be possible to identify some of the deeper surface irregularities with appropriate shadows on the picture. (It may be noted in general that surface marks have quite a different characteristic appearance from internal flaws, and an experienced operator usually neglects surface markings almost automatically.) Having done this, the rest of the marks must be considered. The first illustration shows blow-holes in castings. By "blow-holes" are meant voids due to gases from the sand mould. Fig. 7 is a radiograph obtained from a T-ring clearly showing a series of cavities. Fig. 8 is a diagram illustrating the manner in which the X-rays were passed through the specimen, and Fig. 9 shows photographs of the sections cut after radiography.

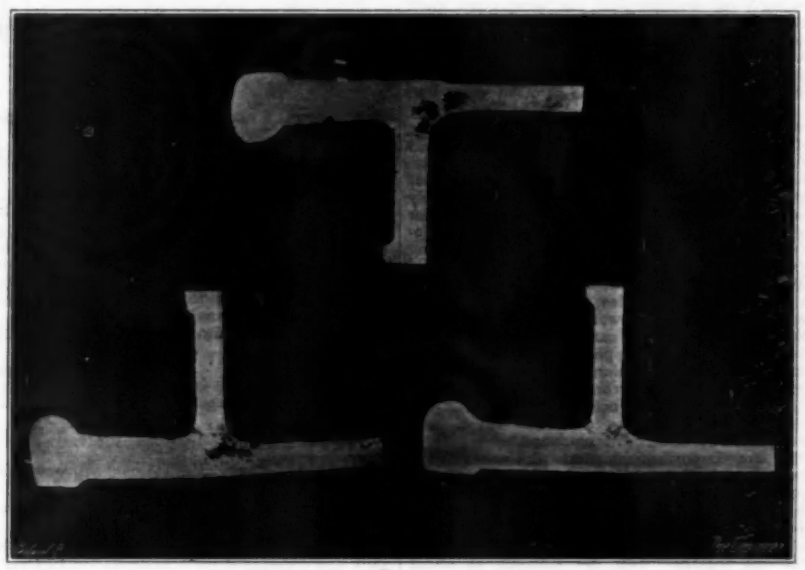


FIG. 9

Sections of Casting. (See Figs. 7 and 8.)

FIG. 7

Radiograph showing extensive "blowing" in a Steel Casting.

It should be very clearly understood that radiographic examination is expensive and, therefore, is not an economic proposition for all castings as a routine matter, although, in the case of very high-grade material where lightness and soundness are of paramount importance, it may even pay to conduct an examination of every casting. On the other hand, X-ray examination should prove of the greatest value in a foundry where castings of new and complicated design could be examined on the spot for weak areas and faulty technique. It is the definite experience of the author that valuable time may be saved by the use of X-rays at the appropriate moment in the foundry.

Another type of specimen that may sometimes be usefully examined by X-rays is forgings. Frequently the problem consists in finding by X-rays the depth of a small surface crack or other similar defect. In general, it may be dealt with on the lines of the experiments that have been described in the investigation of artificial cracks, but occasionally the radiologist is faced with an expensive forging which may exhibit an extensive crack of appreciable width. He is required to state its depth and possible extent beyond its visible boundary. The method usually adopted is a stereoscopic one.

It has been said that the penetrating power of the rays depends upon the voltage applied to the X-ray tube. While this is perfectly true theoretical considerations suggest that the amount of scattered radiation will increase very rapidly at the same time, hence we may suppose that we shall reach a stage when the amount of scatter from the specimen will be so great that all useful contrast on the negative will be destroyed. It is probable that this condition of affairs may materialise at a voltage of something considerably over 300,000. On strictly theoretical grounds it is possible to argue that it will occur at a lower voltage, and, consequently, that it is not very much good to aim at the penetration of very thick masses of steel. An interesting experiment, however, was performed by the author which showed very conclusively

that as voltages are increased up to 285,000 X-ray penetration does, in fact, usefully increase. It is probable that a voltage of 300,000 will enable some 6in. of steel to be penetrated, but so far this has not been realised in a practical manner. The maximum voltage at which it is possible to work consistently is 240,000 volts, giving a penetration of some 4in. of steel. The desirability of examining thicker steel specimens is obvious, because the saving of labour on machining unsound material is very considerable when extremely heavy ingots are involved, and the practical value of X-rays in such cases will become more spectacular. At the same time the method has at present a very extensive sphere of usefulness if its limits are realised and it is applied with sound judgment.

The limiting fact at present in the X-ray penetration of steel is the X-ray tube itself. Tubes to work at 300,000 voltage have been made, but they are not at present a practical proposition, though considerable progress has been made in their design and construction during the last few years. The question of adequate protection for the operator and his assistants is, of course, a vital one, and hitherto has imposed strict limitations on the adaptability of the equipment. It has meant up to now that the X-ray tube had to be enclosed in a heavy and cumbersome lead box specially designed with regard to the stringent electrical conditions, and also fitted with carefully made diaphragms to allow for the emergence of the rays. Radiography owes a great debt to Messrs. Phillips, of Holland, for the introduction of the "Metalix" X-ray tube, which is so constructed as to be self-protecting and so requires no heavy tube box. These tubes may be obtained at voltages up to 240,000 and lend themselves remarkably well to metal radiography. It is also to be noticed that very similar tubes are made in England under the name of the "Protex ray" tubes, although these instruments are designed for very much lower voltages.

Let us now consider the practical application of X-rays. It is obvious that a universal routine of 100 per cent. examination of castings and forgings is out of the question by reason of its cost and the time involved in the operation. On the other hand, information may often be obtained from a radiograph that is obtainable in no other way. There are certain cases where specific knowledge as to the soundness of materials is essential and must be obtained if possible in spite of the somewhat heavy cost involved. High-grade castings where saving of weight is of the greatest importance must be sound, and in such cases it may very well pay to X-ray the whole of every casting. In other cases only suspected areas or regions of severe stress may be selected for X-ray examination. An X-ray plant could very profitably be installed in every foundry of any size. Castings of new and complicated design very often give serious trouble in the first batches. Casting practice is by no means so perfect that the cause of failure can be detected at once, and valuable time is often wasted in rectifying faulty technique or design. If the first casting of a new design were X-rayed as a matter of course the weak and faulty areas would immediately become apparent and their detection would at once suggest the remedy. This, in the author's opinion, is one of the most important developments in foundry practice and one that will surely be universally adopted when X-rays become more familiar in the engineering world. There is also a place for radiography in the machine shop. A flaw may develop during machining operations, and it may often be convenient and economical to ascertain its extent before proceeding with expensive work. Such examples as have already been given illustrate this aspect of the work very well, and experience in the use of the method cannot fail to increase its sphere of usefulness. Another application which is already in common use is the examination of assembled articles. Final assembly of such important items as fuses and similar warlike stores is now being checked by X-ray examination as a routine practice in the Government inspection departments of this country.

One of the most important questions that arises in the mind of the prospective user of X-rays is the cost. It is not easy to specify it. Actually all heavy engineering X-ray work is photographic, as visual examination by means of a fluorescent screen is not often possible. Consequently one of the chief items to consider is the cost of the film. This works out together with development at about 1s. 6d. per square foot. The capital cost of the equipment may be anything from £500 to £1000, depending upon power and installation facilities. Depreciation is low and running costs for power and consumption almost negligible. The cost of the film may be appreciably reduced by the use of specially made sensitised paper which has the disadvantage of requiring something like twice the exposure; but by its use the cost is reduced to about 6d. per square foot. Great improvements have recently been made in the manufacture of this paper, and its use in industrial radiography will probably become general.

There is another possible application of X-rays which may prove to be of extreme value, and that is for welding. X-rays may be used to examine actual welds in order to detect bad metallic union, blow-holes, &c., but their use in this capacity will necessarily be restricted to comparatively small specimens. It is at present out of the question to consider, for example, the use of X-rays in the examination of a long welded pipe line. On the other hand, the question of the X-ray examination of welds in specific instances is well worth consideration if the importance of the work justifies the special examination.

It is well known that X-rays may be used to investigate the crystal structure of metals. Indeed, it is one of the most sensitive methods of detecting change of intercrystalline orientation and grain size following heat treatment or cold working.† This particular technique has a very definite application in the investigation of the art of welding. The condition of the metal adjacent to a weld is one of the most important factors in determining welding technique, and the spectrograms obtained by a system which the author has developed entirely at Woolwich afford valuable information concerning this matter.

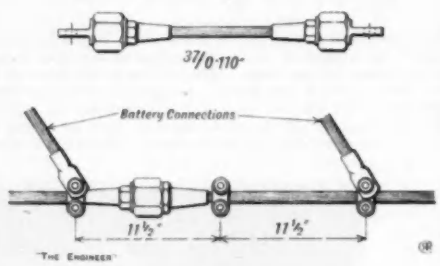
It would appear that the immediate value of X-ray research in welding is chiefly to be found in the use of spectrum analysis as an agent in the investgation and ultimate control of the welding process. At the same time its value in the direct examination of welds in small articles of great importance such as aeroplane components is at present well established. It will be realised that the economic value of all forms of radiology in engineering depends very largely upon the correct design of apparatus and technique, and it is very strongly recommended that the advice of an expert should be sought in specific cases where its adoption is under consideration.

X-ray examination has now established its place in modern engineering activity; like many other innovations, its value is by no means quickly appreciable, but it requires very little scientific foresight to predict an ever-growing demand for the development of this unique method of inspection. To expect too much of the new science is to court disappointment, but at the same time to submit our problems to experiment may be to learn even more than we anticipate.

† THE ENGINEER, 1930, Vol. 150, page 2.

The Jointing of Steel Cored Aluminium Conductors.

THE wide and ever-increasing use of steel reinforced aluminium for overhead power lines has encouraged the design of simple and effective fittings for jointing the conductors in the middle of spans, and for terminating the conductors. In such situations it is imperative that the conductivity and mechanical strength of the joint should be at least equal to the corresponding characteristics of the strand itself. Tests have been made recently at the Prescot Works of British Insulated Cables, Ltd., on the firm's patented aerial cable union, and the tests show that this type of joint complies fully with the requirements. We give below the results of tests on a 37/·110 steel cored aluminium cable union. Two mechanical tests were made on two ending fittings arranged as Fig. 1, and in the case of test No. 1, breakage occurred at 17,770 lb., whilst in the case of test No. 2 at 18,280 lb.



FIGS 1 AND 2—AERIAL CABLE UNIONS

The B.E.S.A. theoretical ultimate strength of the strand is 17,722 lb.

A joint was then made up, as shown in Fig. 2, with a small length of cable each side, and contact clamps were fitted on each side of the joint at 11½in. centres. A third contact clamp was fitted on the strand at 11½in. centres from one of the others, thus enabling the conductivity of the strand and the joint to be directly compared. It should be mentioned that the joint was filled with an anti-corrosive compound.

The following results were obtained with 410 ampères flowing:—

	Millivolts.
Drop across joint and strand	22·2
Drop across 11½in. length of strand	25·0

Resistance of joint and strand $\frac{\cdot 0222}{410} = \cdot 0000542$ ohms

Resistance of strand $\frac{\cdot 025}{410} = \cdot 000061$ ohms.

Relative conductivity of joint to strand $\left.\begin{matrix}\\\end{matrix}\right\} = \frac{\cdot 000061}{\cdot 0000542} = 112 \cdot 5$ per cent.

A current of 350 ampères was then passed through the joint and conductor for 1 hour, and a further test made with the following results:—

Drop across joint and strand at 295 ampères	16·4 millivolts
Drop across strand only at 295 ampères	18·6 "

Resistance of joint $\frac{\cdot 0164}{295} = \cdot 0000556$ ohms

Resistance of strand $\frac{\cdot 0186}{295} = \cdot 000063$ ohms

Relative conductivity of joint to strand $\left.\begin{matrix}\\\end{matrix}\right\} = \frac{\cdot 000063}{\cdot 0000556} = 113$ per cent.

South African Engineering Notes.

Electricity Development.

A NEW power station was put into commission at Pietersburg in September. It contains two 6000 lb. B. and W. boilers, with mechanical stokers and economiser; two new 150-kW Belliss and Morcom A.S.E.A. generating sets, and one 150-kW set from the old station, with condensing plant, cooling pond, and a Reyrolle switchboard. The steel stack provided will take care of future boiler plant and extensions. The estimates for an electricity undertaking to cost approximately £21,000 have been accepted by the ratepayers of the municipality of Louis Trichardt, and the contract will shortly be placed. The power station will contain two 3000 lb. boilers and two 100-kW engine-driven alternators. The electricity undertaking at Paulpietersburg was officially put to work in September. The contract, as is becoming the usual procedure, was placed with a German firm. The first of the inquiries for new plant for power station extensions at the town of Kingwilliamstown has now been issued and covers two 1250-kW turbo-alternators, switchgear, spray cooling equipment, &c. Tenders were due on December 2nd. The consulting engineer to the town of Queenstown recommends the immediate installation of two 1000-kW turbo-alternators and two 8000-lb. boilers, duplicates of the two already installed. Forced draught equipment is to be added and the existing "half" economiser completed—to full size. A new feed pump will be required, also a new spray cooling pond. Provision is made for a water softening plant. The cost of these extensions is estimated at £30,000. Since the present power station was put into commission in May, 1927, the number of consumers has increased from 988 to 1200, the average price per unit sold has fallen from 6·4d. to 4·76d., and the number of units sold has doubled; the maximum load has increased from 230 kW to 485 kW (June, 1930), the revenue has increased from £12,164 to £17,294. Work on the extensions to the power station buildings and plant at Port Elizabeth are being rapidly pushed forward. A 50-ton Morris crane has been erected, which will facilitate a start being made on the erection of the 12,500-kW turbo-alternator, and Mr. Falconer, of Messrs. Parsons' erection staff, has arrived from Newcastle to supervise the installation of this machine. The new Reyrolle generator and feeder board is now completely erected. The Pretoria City Council has accepted the offer of Messrs. Reynolds, Sons and Partners for the supply and erection of the pipe work and auxiliaries which will be required for coupling up the 40/60,000 lb. per hour boiler, now in course of manufacture, to the existing steam and water ranges. The estimated cost is £6200. The position at Johannesburg is that the new power station has a full load output of 30,000 kW, supplied by three 10,000-kW turbo-alternators, with the necessary boiler plant, and it is now proposed to install a further 30,000 kW in two units of 15,000 kW each, bringing the total capacity of the station up to 60,000 kW, which should suffice Johannesburg for some years to come.

Life of the Mines.

Within twenty years the Union's gold production is expected by the Government Mining Engineer, Dr. Hans Pirow, to decrease from £43,500,000 in 1930 to £10,000,000 in 1949. These figures were prepared at the beginning of the present year. Dr. Pirow shows that the peak of the Union's gold production will be reached in 1932, when the value of the product is expected to be £43,800,000. From that stage a steady decline is anticipated, and by 1940 the production is estimated at £25,500,000, while in 1949 it may be only £10,000,000.

Durban's Electrical Consumption.

For the year ended July 31st, 1930, Durban's Electrical Department sold 90,521,589 units, an increase of 12 per cent. on last year's total of 80,733,496. As showing the effect of the domestic load, nearly half the units sold—44,455,774 to be exact—were used for private lighting and heating, an increase of 17·5 per cent. over last year. Of this total, 33,187,995 units were sold at from ¼d. to 1d. each, representing more nearly the actual cooking consumption. This figure shows an increase of 20·5 per cent. Private power units totalled 24,633,061, an 8 per cent. increase over last year; Government lighting and power, 9,574,295 units, or 5·8 per cent. increase; tramways, 7,040,726, also 5·8 per cent. more; the balance comprising 2,638,768 units, used for street lighting, an increase of 11·3 per cent., and 2,178,968 for power and lighting in the various municipal departments, a 7·2 per cent. increase. The units delivered to the supply mains totalled 100,544,048, of which 4,656,710 units were provided from the small but highly efficient "waste heat" plant at Hulett's sugar refinery, Rossburgh. The maximum load on the system as registered was 29,200 kW, though it exceeded 30,000 kW for brief periods, the annual load factor being 39·31 per cent.

Joint Sewerage Scheme.

A proposal for a joint sewerage scheme for the towns of Germiston, Boksburg and Benoni, on the Witwatersrand, is being considered by the respective town councils. The establishment of a Board to control the sewage of the whole area, including all main sewers, sewers in the town and the house connections. In that case the cost of the running of the Board would be met by charging a uniform sewerage fee on all properties draining to the sewers within the jurisdiction of the constituent councils. The estimated cost of the joint scheme is £197,140, subject to details which might mutually be agreed.

New Railway Line.

The Empangeni-Nkwaleni Railway, Natal, was opened at the end of September. The line, which traverses the farming area of Ntambonana, is 40 miles long and was built at a cost of £228,000. The terminus of the railway is at Nkwaleni, and connection is made with the North Coast line at Empangeni. The line will serve a large sugar cane area. The country through which the line runs is mainly Zululand, Natal.

Rhodesia-Walvis Bay Railway.

At the Rhodesia Party Congress in October, resolutions endorsing the Government's steps regarding the amalgamation of the two Rhodesias and favouring the incorporation of Bechuanaland and the Tati Territory and also favouring the Walvis Bay line were passed unanimously. Mr. Downie, Minister of Mines and Works, said, with regard to the Walvis Bay line, that the survey would probably be completed at the end of September or October next year, and that all details would be incorporated in the engineer's report when the survey was completed. There was no question about the desirability of the line, but the extent of its practicability could only be ascertained when the reconnaissance was completed. From the point of view of making revenue and expenditure balance the line was not practicable, but that would not deter the Government, which was prepared to face that issue. On the question of route Mr. Downie said that there was not much difference in the distance from the suggested starting point of Plumtree, Wankie and Matetsi to Gobabis. They had decided that the route starting from the neighbourhood of Wankie was the best, for it offered the greatest possibilities from the view point of bulk of traffic and provided the shortest route for the greatest

tonnage. The best way of getting the line would be to make it part of the railway system and endeavour to have a single system of railways in the country. One point was not generally understood, as far as Bechuanaland's contribution of traffic to the line was concerned, namely, that it was the policy of the present Bechuanaland Administration not to develop the country for European settlement. "The Government recognises the desirability of this line," said Mr. Downie, "and we will leave no stone unturned to bring it as close to the range of practical politics as possible."

Bloemfontein Waterworks.

Work is now in progress completely to reorganise and electrify the Bloemfontein municipal waterworks at Magilspoort. The whole scheme is estimated to cost £40,000. The new pumps, motors, &c., supplied by Messrs. Rennert and Lenz and Messrs. Dawson and Dobson, Johannesburg, will supply the new filters. It is anticipated that this new scheme will cope with the demand up to 1945, and the plant can be augmented as required.

Coal in Northern Rhodesia.

Various opinions have been expressed regarding the quality of the coal found in Northern Rhodesia in which Sir Robert Williams and Co. are interested. An official statement has now been issued by the Rhodesia Katanga Company, which holds an interest in the finds. It states that the coal areas in question extend over 62 square miles at Hot Springs, 160 miles to the south of the Kansanshi Mine. Three of the areas have been investigated by diamond drill holes, and three seams of coal proved. The Kafue and Luano coal is admitted to be of similar type to that obtained from the Lueno Colliery in Katanga, which is used on the Belgian Congo Railways, and also for metallurgical work at the smelters of the Union Miniere in Katanga. In quality, therefore, it is a long way inferior to the Wankie product, and it is questionable if the cost of building a railway to the new coalfield is a business propsition.

Cape Town Harbour.

Notwithstanding occasional spells of unfavourable weather during the winter season, steady progress is being made with the Cape Town harbour extensions works. At the end of August 886ft. out of a total of 1500ft. by which the breakwater is to be extended, had been fully completed, involving placing 4433 40-ton blocks in position. At the same date 4219ft., or approximately 76 per cent. of the total authorised length of the random block mole, had been completed, involving the dumping of 35,550 concrete blocks. The south side of the South Arm was first used for berthing a vessel towards the end of August, but a large amount of work is still required to complete the proposed extensions. Apart from the erection of shed accommodation, most of which will be of two storeys, a large amount of filling in has yet to be done to form the quays, 10,000 yards of railway track have to be laid and about 1,300,000 cubic yards will have to be dredged. When fully equipped, the Table Bay docks will have seventy-two electrically-operated cranes, varying in capacity from 60 to 4 tons, nineteen of which will be installed on the new South Arm. Some 550 men are employed on the work now in hand.

CONTRACTS.

MAVOR AND COULSON, Ltd., of Glasgow, have received from the Russian Government an order for 250 coal cutters.

RICHARD DUNSTON, Ltd., asks us to announce that its Thorne shipyard has secured an order for three 60ft. tugs for the London and North-Eastern Railway Company.

THE CHANTIERS ET ATELIERS AUGUSTIN NORMAND, of Havre, have received from the French Admiralty orders to supply the propelling machinery for two submarines which are being built in Government yards. One set of machines will comprise two Vickers-Normand solid-injection heavy-oil engines, each of 650 H.P., the other set comprising two engines of the same type, but each of 900 H.P.

J. W. BROOKE AND CO., Ltd., of Lowestoft, have received an order for a batch of their 10 H.P., four-cylinder, "Empire" motors, type 10–D/30, for installation in Persian patrol boats. The same firm has received orders for a total of eight 100 H.P. six-cylinder O.H.V. engine units for installation in 35ft. motor boats which are being built by Harland and Wolff, Ltd., and Rutherford and Co. for the British Admiralty.

THE STIRLING BOILER COMPANY, Ltd., 32–33, Farringdon-street, London, E.C. 4, has received an order for two tri-drum Stirling boilers, each having a heating surface of 9814 square feet, working pressure 425 lb. per square inch, final temperature 775 deg. Fah., normal evaporation 75,000 lb. of water per hour, maximum 100,000 lb. of water per hour, complete with economisers, air heaters, mechanical stokers, forced and induced draught plant, chimney and grit arresters, and ash-handling plant, &c. This plant is for extensions to the North Point Power Station of the Hong Kong Electric Company, Ltd.

GREAT WESTERN RAILWAY COMPANY officially announces that the following orders, in order of value, have been placed:—(*a*) Construction of a new roof, approach road, retaining wall, and other works for a new parcels depôt, Bishops-mews, Paddington Station, Holliday and Greenwood, Ltd., London, S.W. 1; (*b*) supply and erection of a movable coal hoist and electrically operated traverser for Queen Alexandra Dock, Cardiff, the Hydraulic Engineering Company, Ltd., Chester; (*c*) steel jetty to carry a new coal conveyor at the north-east end of Roath Dock, Cardiff, Geo. Palmer, Neath; (*d*) supply and erection of one electric 30-ton Goliath crane, at Morpeth Dock, Birkenhead, the Clyde Crane and Engineering Company, Ltd., Mossend, Lanarkshire; (*e*) the supply and erection of one 20-ton electrically driven Goliath crane at Wolverhampton Herbert-street goods yard, the Clyde Crane and Engineering Company, Ltd., Lanarkshire; (*f*) the supply and erection of two electric 30-cwt. goods lifts at Swansea High-street warehouse, Evans Lifts, Ltd., Leicester; (*g*) additions to garage at Ladbroke-grove, London, W., Wm. Walkerdine, Ltd., London; (*h*) asphalting down platform at High-street, Newport, the Western Trinidad Lake Asphalt Company, Ltd., Cardiff; (*i*) the supply and erection of one 3-ton electric capstan at Glasgow Wharf, Plymouth Dock, Ransomes and Rapier, Ltd., London; (*j*) a new kiosk on the down platform at Exeter Station, Wm. I. Nicholls, Ltd., Gloucester; and (*k*) the supply of a steel-framed building at Evesham, J. Tildesley, Ltd., Darlaston.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(*From our own Correspondent.*)

The Approach of Christmas.

THE near approach of Christmas, with its temporary cessation of activity at the works, is having a marked effect upon iron and steel business. On 'Change in Birmingham this week very little buying took place, and there was an absence of active interest in any department. Midland consumers of iron and steel have, almost in all instances, sufficient material to meet their needs to the end of the year, and as the outlook for 1931 is still very uncertain, they consider it unwise to enter into negotiations ahead of known requirements. Trade depression continues severe in the greater number of Midland and Staffordshire industries, and in some areas where the heavy trades predominate the position at date is considered acute. Industries particularly hard hit just now include the heavy edge tool, nut and bolt, and chain and anchor trades. Iron and steelmasters have this week, in an endeavour to secure orders, been pointing out the possibility of advances in raw material prices in the near future as the results of control in the coal trade. Though admitting the feasibility of such a movement, industrialists engaged in the finishing branches of district industry cannot bring themselves to make purchases. They must, they assert, await the anticipated trade developments of the early part of the New Year. The Christmas holidays have affected earlier than usual the Midland market, and little, if any, activity on the Birmingham Exchange is expected until after the year end.

Pig Iron.

Derbyshire and Northamptonshire blast-furnacemen are satisfied that they are not now losing business to the foreigner. They are further of opinion that there has been more than a little exaggeration as to the amount of business recently placed with continental suppliers. The small-scale buying indulged in during the past few days has been very much on a par with that in circulation before the advent of foreign material into this market. Midland foundries are far from busy, and are only taking delivery of a few tons of pig iron at a time. Forgemen are so unsatisfactorily placed for business that their purchases of raw material are very irregular as well as of small volume. Midland brands of pig iron are meeting with a certain amount of success in the north-eastern districts in competition with Cleveland and Scottish irons. Furnacemen are glad of this additional business, as, with production equivalent to district consumptive requirements, these orders from outside enable them to draw to some extent upon their stocks. These latter they are very anxious to reduce, for in some instances, especially in Northamptonshire, they are becoming unwieldy. There is no change in producers' attitude towards prices, which remain stationary at the basis fixed by the Central Pig Iron Producers' Association. Derbyshire No. 3 foundry is £3 11s. per ton and Northamptonshire £3 7s. 6d. per ton for delivery in the Black Country zone. It is noted that production of pig iron the kingdom over continues to decline, last month's output of 384,100 tons, comparing very unfavourably with the 631,400 tons produced in the corresponding month last year. The production was also nearly 31,000 tons less than in October this year. The furnaces produced last month 143,600 tons of basic pig, 107,500 tons of hematite, 102,500 tons of foundry, and 18,000 tons of forge pig iron. At the end of the month there were only ninety-two furnaces in blast, as against ninety-six when the month opened. The market for blast-furnace coke is quiet and quotations vary somewhat. Whereas in certain cases as much as 13s. per ton is asked, in others business is said to be possible at 12s. per ton.

Finished Iron.

Staffordshire ironmasters are hoping for an enlivenment of business after the Christmas holiday. Some engineering firms appear to be withholding their orders. At any rate, there has been a marked falling away in their requirements during the past week or ten days. All branches of the finished iron trade have experienced the decline, and as order books are thin, a lengthy holiday spell is contemplated at many of the works. It is hoped that during the holiday order books will be reinforced, and that mills will be enabled upon resumption to run with greater regularity than has been the case recently. There have been during the past year many prophecies of better times in store for the finished iron industry, due to a return to favour of high-grade wrought iron, such as is manufactured hereabouts. That the New Year will see these forecasts in some measure verified is the earnest wish of South Staffordshire ironmasters. There is no change in values on the week, marked bars being quoted £12 10s. per ton, Crown bars £10 to £10 7s. 6d., nut and bolt and fencing bars £9, and iron tube strip £10 17s. 6d. to £11 per ton.

Steel.

No improvement in the demand for steel generally has developed since last week; indeed, the position may safely be said to have become slightly worse. The exception is special steel products for motor car manufacture. Here specifications have been rather better, though they are still below normal. Structural steel is in poor request, Midland yards being short of large contracts. The district plate mills are badly off for work, and rolling programmes are difficult to arrange. Finished steel prices are maintained by the Steel Association. Angles are £8 7s. 6d., tees £9 7s. 6d., joists £8 10s., ship, bridge and tank plates £8 17s. 6d.—all per ton and subject to rebate. Boiler plates are quoted £9 7s. 6d. upwards and small bars £7 7s. 6d. Mild steel billets make £5 12s. 6d., and Staffordshire hoops £9 10s. There are fewer offers of continental half-products, and prices are more firmly held. Buyers in this area are, however, looking for a further subsidence in values of foreign semis in the near future. Very little business has been done in the steel department this week, either in native or foreign material.

Galvanised Sheets.

There is no sign of improvement in the galvanised sheet trade. Some works are idle, and others are on short time. Prices have been reaffirmed on the basis of £11 5s. per ton for 24 gauge corrugateds. Overseas markets continue poor customers, and the trading returns for the month of November make poor reading. Shipments during the month amounted in value to only £323,731, as against £782,839 in November last year. It is a regrettable state of affairs.

Imports.

Midland manufacturers and producers of iron and steel were interested to learn that the total quantity of iron and steel imported into this country during the month of November was 209,769 tons, to the value of £1,613,136, compared with 250,430 tons, valued at £2,161,570 in the corresponding month last year. Imports for the year to date total 2,625,309 tons, compared with 2,560,228 tons during the same period last year, the respective values being £21,266,801 and £22,486,956.

Unemployment.

The state of trade in the Midlands is shown by the fact that the unemployment returns still move in the wrong direction. The latest records show further increase in the number of unemployed, bringing the total for the area up to 301,889. Birmingham, Stoke-on-Trent, and Wolverhampton show slight decreases.

LANCASHIRE.

(*From our own Correspondents.*)

MANCHESTER.

After Five Years.

RANKING with the new arterial road from Manchester to Liverpool and the water supply scheme of the Manchester Corporation at Haweswater—both in progress—as the biggest engineering undertakings in Lancashire within recent years, the construction of the new tunnel under the river Mersey, from Liverpool on the Lancashire side to Birkenhead, on the Cheshire side, may now be said to be within sight of early completion so far as the actual tunnelling operations are concerned. The work has been in progress exactly five years—a beginning was made in December, 1925—and no more than about 70 yards of excavation on the land side at Liverpool has to be carried out. This, at the present rate, will take about three months to complete. Difficult problems of ventilation remain to be solved, and experimental work to that end has been in progress for some time. Interesting work is also being conducted with a view to securing a surface lining for the tube, which will be both efficient and attractive, the important factor of corrosive influences, of course, receiving primary consideration.

A New Ring Frame.

Tweedales and Smalley, Ltd., Rochdale; John Hetherington and Sons, Ltd., Manchester; Howard and Bullough, Ltd., Accrington, and Dobson and Barlow, Ltd., Bolton, are said to be included among Lancashire firms of textile machinery manufacturers which have received licences to produce a new inclined mule spindle ring frame that has been brought prominently before the public in this part of the country during the past few days. The great advantage claimed for the new ring frame is that it is possible to produce on it fine cotton yarns equal in quality to those which, up to the present, it has only been possible to spin on mules, and if the claims made are substantiated in large-scale industrial operations, considerable economic benefit to the Lancashire cotton trade is expected to result. The patents covering the new device are controlled by a Preston concern—Textile Underclearers, Ltd.

No Trackless Tramcars for Manchester.

After careful investigation in various parts of the country by members of the Manchester Corporation Transport Committee, an official report was submitted to the Committee on Tuesday of this week, when it was announced that the Corporation had decided not to seek a Parliamentary Bill giving it powers to develop the trackless tramcar system. Few members of the deputation, it is understood, were enthusiastic regarding the trackless system after studying it in operation.

Bitumen in Bulk.

The steamship "Ebano," a special type of vessel which was recently constructed at the Belfast yard of Harland and Wolff, Ltd., for Andrew Weir and Co., arrived at Preston Docks last Saturday from Harburg, on the Elbe, with a cargo of 2500 tons of liquid bitumen. The material is maintained in the liquid condition on board through storage in heated tanks and is pumped into heated bulk containers on the dockside at Preston, transport from the latter to the point of consumption for road-making or other purposes being by means of specially constructed vehicles or railway tanks in which the bitumen is still kept liquid. The storage installation at Preston was erected recently at a cost of about £35,000, and the cargo last week-end was the first of what is expected to be a regular traffic.

Bury's £400,000 Ring Road Scheme.

To relieve congestion in the centre of the town and other parts of the borough, Bury Town Council proposes to carry out a scheme of ring road construction at an estimated cost of £400,000, and details are being submitted to the Ministry of Transport.

Non-ferrous Metals.

Events on the non-ferrous metals market during the past week will prove a rude shock to those people

whose view of late has been that the bottom of the market had been reached. All of the metals have suffered in almost equal degree relative to the selling prices of each. In no section does the statistical position appear to improve, and in each case the stark fact remains that production is much too heavy in relation to present-day consumption. Copper has been very freely offered, with a net loss in standard descriptions compared with a week ago of about £2 10s. per ton, refined metal also being appreciably cheaper on balance. In no direction has there been any anxiety to buy. Much the same conditions have obtained in the case of tin, the loss of about £4 per ton on the week bringing values to a lower point than has been touched for about thirty years. Supplies of lead have been coming forward in big quantities, and with no corresponding expansion in the demand, the metal has been unable to resist the general weakening tendency, and quotations are down by roughly 15s. per ton. The spelter market has been in an almost lifeless condition, and the 10s. fall during the past week has brought prices down to a new "low."

Iron and Steel.

The Lancashire iron and steel markets are in a dull and uninteresting state. Foundry iron consumers in the area have mostly covered their requirements over the next six weeks, and so far as further commitments are concerned the majority of them are prepared to wait and see what, if anything, develops at the January month-end meeting of Midland makers from the point of view of prices. The satisfactory feature of the situation in this section is that aggregate deliveries into consumption are probably fractionally above what they were a month or two ago, although some seasonal contraction may be looked for during the next two weeks. Prices remain at 69s. 6d. per ton for Staffordshire and Derbyshire No. 3, 68s. for Northamptonshire, about 91s. for Scotch, and 84s. 6d. for West Coast hematite, for delivery Manchester or equal distance. Bar iron is quiet but unchanged at £10 5s. per ton for Lancashire Crown quality, and about £8 15s. for seconds. So far as actual prices are concerned, there has been no actual change in either British or foreign steels offered here, and remarkably poor buying interest is being displayed in any section. A slight ray of hope lies in the fact that constructional engineers in the district appear to be anticipating before long a freer flow of municipal orders.

BARROW-IN-FURNESS.

Hematite

There is no improvement in the hematite pig iron market, and it seems very likely that there will be further restriction of output ere long. The two furnaces at Barrow are now damped down and will continue to be idle until present stocks are considerably down. At other works stocks are increasing, and the only alternative is to reduce production partially or completely for a time. At one works in Cumberland the two furnaces are working alternate blasts. There is no sign of any improvement at present, and we will have to wait until the new year before any sign can be expected. The home demand is thin and the same remark applies to trade with continental and American customers. The iron ore trade is feeling the slump keenly and there is a great falling off in business compared with nine months ago. Little can be said of the steel trade, in which there is little activity. It is hardly likely that any more rails will be turned out this year in Cumberland, while at Barrow there is not the faintest hope of any production at present. The hoop mills at Barrow are working.

Shipbuilding.

The news that two destroyers are to be built by Vickers-Armstrongs at Barrow is welcome. It was pretty well known that an Admiralty contract was on the way, and that it would either be a cruiser or two destroyers, but the news was not expected so soon. The early placing of the contract is with a view to reducing unemployment. There are rumours of other orders likely to be placed in 1931, but negotiations are not sufficiently advanced yet to permit any definite statement being made.

SHEFFIELD.

(From our own Correspondent.)

Steel Output Still Down.

THERE is now no hope of any useful improvement in the demand for ordinary qualities of steel this year. The Christmas holiday, which will soon be upon us, will, in many cases, be longer than usual, and no movement of consequence is likely to take place before the middle of January. Not that there is any sign that anything will materialise even then. That the position at present is as bad as ever, is emphasised by the fact that the directors of the United Steel Companies have decided not to declare an interim dividend "in view of the continued depression in the coal, iron and steel trades, and the necessity of conserving the resources of the company." Consequent upon this decision, no interim dividend will be paid on the 6½ per cent. preference shares of Steel Industries of Great Britain, Ltd. There is, in the Sheffield area, which includes Lincolnshire, a total of 119 acid and basic open hearth furnaces available, and of them only 33 are operating. Allowance has to be made for the fact that some furnaces are usually down for repairs, but even then the proportion in commission is no more than about 34 per cent. There is no regular flow of orders, even on a small scale, while bulk business is almost entirely absent.

The General Position.

There are few or no departments of Sheffield trade which can be described as being in a really satisfactory position. Among the best are those producing stainless and non-corrodible steels, and steel and parts for motor cars, but they are below the level to which they were accustomed a year ago. There are some very good orders on hand for railway buffers, but the shops devoted to the production of axles, tires and springs, are very thinly employed. There is a large demand for hacksaws, but not many other classes of tools are in any great request. While there have been improved sales of special steel lately, the position of that important product is far from satisfactory, and there has been a falling off in exports.

Shipbuilding Work.

Reports have been current for a week or two with regard to the Admiralty programme of naval work, and an official statement on the subject was made in Sheffield last Sunday by Mr. A. V. Alexander, the First Lord, who sits for one of the city's Divisions. His announcement was of much interest to Sheffield, for the orders will benefit shipbuilding yards belonging to local firms, and will also bring work to the city itself, both in the production of forgings and in the call for shipbuilders' tools of various kinds. Mr. Alexander stated that during the next few weeks orders for a cruiser and eight destroyers would be placed in depressed areas. The cruiser, with machinery complete, is to be supplied by Cammell, Laird and Co., Ltd., and it is expected that that firm will be enabled to reopen the south yard of its Birkenhead works, which has been closed for some months through lack of orders. Vickers, Ltd., at Barrow, are to build two destroyers and a set of machinery, and orders of a similar character are to be placed on the Clyde and on the Tyne, while two destroyers are also to be constructed at Southampton. All this work will cost approximately £6,000,000, and, with materials for sloops, submarines and cruisers to be built in the Government dockyards within the next few months, will total over £8,000,000. Mr. Alexander stated that the total cost of this year's programme was estimated at £9,500,000. The demands on Sheffield for ordinary shipbuilding supplies are, at present, on a low scale, as they have been for some months. John Brown and Co., Ltd., as I have previously mentioned, are more favourably placed in this department in consequence of their having booked the order for the giant Cunarder. The main items which that contract will bring to the firm's Sheffield works are the shafting, pinions and the large boiler and turbine drums produced by the new system of hollow forging, representing, altogether, a great amount of heavy forging work.

Aeronautical Research.

During the summer I recorded the production, by John Brown and Co., Ltd., of a variable density tunnel for use in high-speed aeronautical research at the National Physical Laboratory, Teddington. After undergoing a preliminary test in Sheffield, this great structure was dismantled and the pieces taken by road to Teddington. It has now been re-erected there on its permanent site, and about a week ago it was again subjected to a hydraulic pressure test of 550 lb. per square inch, which was entirely satisfactory. The re-erection was entrusted by Messrs. Brown to Markham and Co., Ltd., of Chesterfield, who also supplied the internal fittings.

Trade Missions.

Sheffield is to the fore in important trade missions to distant countries. The Mission to South America, headed by Mr. A. K. Wilson—ex-Master Cutler—is expected to return this week-end, after an absence of several months, during which much good work has been accomplished in spreading the knowledge of Sheffield products in various important markets. Now comes the news that Sir Arthur Balfour is to be the chairman of the United Kingdom Trade Mission to Egypt, which the Government will despatch early in the new year. Sir Arthur will concern himself principally with finding new markets for iron and steel. It is understood that he will be accompanied by Sir Alan Anderson, representing the engineering industry, and Mr. Kenneth Lee, for the cotton industry.

Co-operation in Stainless Steel.

An important move to develop co-operation in the stainless steel trade has recently been carried out by the Sheffield Stainless Steel Manufacturers' Association and the Firth-Brearley Stainless Steel Syndicate, Ltd. Customers of the Manufacturers' Association—which includes about 15 well-known firms—may, under licence from the syndicate, export articles made from stainless steel to all the foreign countries where their patents are in force. An agreement has been made with Messrs. Krupp, who control the patent position in Germany, for elimination of competition in the British Isles in stainless steel and articles made therefrom by German, Austrian, and Czecho-Slovakian manufacturers. This ensures a valuable means for "safeguarding" British products, which has already proved of very great benefit to the Sheffield trade and other British firms using stainless steel. There is also another item of interest in connection with stainless steel, in a report that negotiations are taking place with a view to the formation of a company in Sheffield to manufacture from that material a large range of domestic articles, including ash trays, door knobs, water taps, spoons and forks, locks and hinges, kitchen utensils, electric fittings, stair rods and fire irons. Such a project would have the effect of establishing in Sheffield a new industry, which is now almost confined to Birmingham. It is proposed that the company should have a capital approaching £1,000,000.

No Electrification.

Some time ago it was announced that the London and North-Eastern Railway Company proposed to electrify its line from Sheffield to Manchester, and one of the advantages which was expected to ensue was a great saving in fuel costs, owing to the heavy gradients on the section. It is now stated at the headquarters of the company, however, that it is not intended to proceed with the plan for the time being.

Looking for an Aerodrome.

The Sheffield Corporation has retained Sir Alan Cobham in an advisory capacity on the subject of the provision of an aerodrome for the city. Sir Alan has examined the country round Sheffield, within an area of 200 square miles. I understand that he has found several sites which he thinks may prove suitable, and has reported upon them in detail to a committee of the City Council. None of the sites is more than 7 miles distant from the centre of the city.

Cutlery and Plate.

The seasonal demand for these products, which has now nearly drawn to a close, has provided a substantial amount of work, especially in the medium and cheaper classes of goods. There has also been a good demand for high-class pen and pocket knives, but the trade in best ivory-handled table cutlery shows a falling off. The value of the cutlery exported during November was £71,074, which was about equal to the figure of October, but £37,000 down on twelve months ago. The Australian market showed an improvement as compared with the previous month; but there was a sharp decline in New Zealand. An advance was recorded in the export of complete safety razors, but with regard to blades the case was opposite. The total exports for the eleven months to date show a decline of £250,000. Imports in November were only £22,710, as compared with £57,676 in October. The fall is not to be wondered at, in view of the imminent lapsing of the Safeguarding Duty, after which importation will be cheaper.

NORTH OF ENGLAND.

(From our own Correspondent.)

Iron Trade Future.

A UNIFIED control of the iron and steel firms on the North-East Coast is a possibility of the next few years, which would not surprise Sir Hugh Bell, Bart., the veteran Teesside ironmaster. He prophesied this development at Middlesbrough this week to the shareholders of Dorman, Long and Co., Ltd. "Sir Arthur Dorman and I," said Sir Hugh, "may fairly claim to have embarked a good many years ago on a process to which we gave no specific name, but which has always had the effect of broadening the basis of our operations. We sought to found them on the raw material, and then to carry them further and further in the direction of still more finished products, until Dorman, Long and Co. are not only owners of mines, collieries, blast-furnaces, rolling mills, and constructional works in this country and various countries, British or foreign overseas, but stand among the leading bridge-builders of the world." The process, Sir Hugh added, was probably not complete. It would be surprising if within the next few years they did not see the iron industry of the Tees, or possibly of the North-East Coast generally, being centred more and more under one control.

Cleveland Iron Trade.

The Cleveland iron trade presents no new features of moment. Business has declined still further, the general disposition being to suspend transactions until after the holidays. Practically every consumer has sufficient for prompt needs, and deliveries in some cases will be suspended. Moreover, the steel works will be closing for the holidays, and on that account alone, there will be a big surplus of iron which will have to go into stock until such time as trade improves sufficiently to provide an outlet. Exports, too, are tapering off, and there is a growing belief that the ironmasters may have to yield to "bear" pressure. At present, however, prices are maintained, No. 1 Cleveland foundry iron being 66s., No. 3 G.M.B. 63s. 6d., No. 4 foundry 62s. 6d., and No. 4 forge 62s.

Hematite Pig Iron.

A feature of the East Coast hematite pig iron trade this week has been the sale of fair quantities for shipment to Denmark. Home business has dropped away, but this is the usual experience at this period of the year. Mixed numbers remain on the basis of 71s., but terms of contract vary after individual bargaining. No. 1 quality is at a premium of 6d. per ton.

Iron-making Materials.

The foreign ore trade is practically at a standstill, consumers having large stocks and big deliveries to take under running contracts. Quotations are based on best Rubio ore at 16s. 6s. for prompt c.i.f. delivery, and 17s. for forward delivery. Blast-furnace coke is rather firmer at 17s., delivered at the works.

Manufactured Iron and Steel.

Sales of manufactured iron and steel commodities are as difficult as ever to effect, and demand for semi-finished materials continues very quiet. In most departments plant is far from fully employed, and orders are urgently needed to enable producers to maintain tonnage output. Foreign products are still offered at greatly below quotations for the manufactures of this area. Prices are unchanged

Tees Shipyard May be Reopened.

There is a prospect of the reopening of a derelict Tees shipyard. Negotiations are taking place between the South Stockton Shipbuilding and Engineering Company, Ltd., and the receiver appointed in connection with the dismantled shipyard site of Richardson, Duck and Co., Ltd., Thornaby-on-Tees. It is understood that if terms for the purchase of the land can be arranged, the yard will be constructed for the building and repairing of trawlers, barges, and similar small crafts, and that trawler owners are interested in the transaction. It would seem that there is a growing disposition on the part of owners of trawlers to have their own building and repairing facilities rather than to have to send their boats in many instances on long voyages to be overhauled and repaired. The experiment was recently tried at West Hartlepool, and gives promise of being a successful venture. The shipbuilding

yard of Richardson, Duck and Co. was opened in 1854, and through trade depression was closed in 1925. Four years later the yard was dismantled. It is now a valuable vacant site, with good river frontage and most suitably situated for the purposes for which the negotiations are taking place.

Wearside Works Development.

A noteworthy industrial development on Wearside was started this week. T. S. Forster and Sons, Ltd., of the Bank Forge, Pallion, Sunderland, some time ago acquired the site of an old forge at South Hylton, upon which they have erected one of the most up-to-date forging establishments in the north. In this there is notably a 1000 tons hydraulic forging press, complete with the latest type of equipment, including waste heat boiler, heat-recovery plant, and annealing furnaces, with overhead electric cranes, capable of handling ingots up to 25 tons. The works at the start will employ 400 men.

The Coal Trade.

The usual holiday pressure for small quantities of coal for filling up tonnage already stemmed is being experienced in the Northern coal trade. The supply is very limited, as all the owners in both counties report being full of trade up to the end of the month. In the absence of any definite news, it appears that the minimum prices which are to be fixed for Durham coals for export are still in the process of being settled. It is stated, however, that the weighty task of classifying and grouping the Durham qualities preparatory to fixing prices has already been accomplished. In Northumberland the coal committee is busy deciding minimum selling prices for the grades of coal used at home. For next month's shipment, business is not coming forward very freely, but coal producers abroad are reported to be transacting a good trade by virtue of their lower prices. Best Northumberland steams are quoted at from 13s. 6d. to 13s. 9d. and 10s. for smalls. Durham gas coal for prompt is very firm, and recent top prices are not discountable. Best qualities command 15s. Secondary gas coals are well booked up, and quoted steadily at 13s. to 13s. 9d. Durham coking unscreened coals meet with keen pressure for early shipment. Best qualities are very steady at 13s. 6d., and ordinary at 13s. Among cokes, gas makes are easily the strongest. Makers are practically sold out for this year. Ordinary patent foundry and blast-furnace cokes are in moderate request.

SCOTLAND.

(From our own Correspondent.)

Unchanged Conditions.

GENERAL conditions in the steel, iron, and coal trades show no change from those prevailing for a long period. Inquiries on occasion have been more numerous, as is the case at present, but few of them develop into orders. The end of the year is in sight, but there is no sign of any inclination on the part of consumers to anticipate requirements over the holidays, even though in some instances the vacation may be prolonged, owing to the state of trade.

Steel and Iron.

Steel works in Scotland are already curtailing production in view of the holidays, and in order to conform more closely with market requirements at the moment, it is understood that in many cases the holidays will extend to a fortnight at least. The outlook has not improved with the easier conditions again apparent on the Continent, where sheet bars, for instance, have been on offer at 75s. per ton, 2s. 6d. cheaper than in the preceding week. The International Steel Cartel has been renewed until June, 1931, and production during January, February, and March will be reduced a further 5 per cent., making the full curtailment 30 per cent. This arrangement may have a beneficial effect on trade here, when the heavy stocks held on the Continent have been reduced or dissolved. Scottish tube makers are very quiet. Some works are closed and others are working on three days on alternate weeks. The present output is well below 50 per cent. of capacity. It is said that even at this rate of production, British makers find some difficulty in keeping within the limits of their export quotas under the International Cartel arrangements. Sheet makers continue to feel the effects of the absence of demand from Eastern markets, and the complete cessation of business in galvanised sheets with Australia.

Iron.

The outlook in the iron trade is not any more hopeful. Wrought iron and re-rolled steel bars are very short of orders. Competition is very keen for any export business on offer, and the quoted prices are not always adhered to. Bar iron is at £10 5s. home—fixed—£9 15s. per ton export. Re-rolled steel bars £7 7s. 6d. home and £7 5s. per ton export. The output from the ten pig iron furnaces in blast is still quite sufficient to meet all demands, owing to continued depression in the consuming trades, and further importations from India and the Continent.

Scrap

Business in scrap is confined to small lots, with prices in the recent levels of 60s. for cast iron machinery and 50s. per ton for heavy steel.

Coal.

Though the decision to resume work was announced over a week ago, the miners have been slow to come back to the pits, and the production has not yet reached pre-strike proportions. Consequently, with the collieries in arrears with home and export deliveries, there is very little fuel available for prompt disposal. So far as new export transactions are concerned, prices are still too high to make business a practical proposition. Aggregate shipments amounted to 120,673 tons, against 126,359 tons in the preceding week and 218,254 tons in the same week last year. For land sale prices are again almost normal, but export figures are nominal.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Wages Agreement Negotiations.

IT is a regrettable fact that no progress has been made towards a permanent or temporary wages agreement during the past week. There is, of course, a temporary agreement in operation between the coalowners and the miners, but it expires at the end of December. Taking the Christmas holidays into consideration, the time available for negotiation is becoming dangerously short. There have been some developments since I wrote a week ago, though they do not carry the parties far along the path of progress. The special conference of coalfield delegates held at Cardiff on Saturday last adopted the recommendation of the executive that the miners should accept the suggestion of the Prime Minister that the Federation should give the industry a chance to get its reorganisation schemes under the Coal Mines Act working effectively by approving the "spreadover" application for a temporary period of three months without any reductions in wages. In this connection, the important provision was made that the "spreadover" of hours should be on a weekly basis, instead of fortnightly. The reason for the stipulation is that under the fortnightly "spreadover" the miners lose one day a fortnight, whereas under a weekly basis of forty-five hours this loss of a day's work is avoided. The coalowners are not opposed to the weekly basis of forty-five hours, which means 7½ hours' work each day, provided it is on the basis of equivalent pay for equivalent work. This means that for a forty-five hour week there would have to be a revision of wages rates, to which, of course, the miners are opposed. On Monday the Joint Sub-committee of the Conciliation Board met to resume negotiations, but all that can be said of the proceedings is that a deadlock was only just avoided, because the meeting was adjourned until Tuesday of next week. The official report shows that no progress was made. The coalowners endeavoured to persuade the men's representatives to discuss the question of what the industry could pay in wages under the reduced hours, and, further, that if the parties failed to agree, points at issue should be referred to an independent chairman. The owners also made it clear that under no circumstances would they appear before the National Industrial Board. The position therefore is now that the men's leaders have not accepted the owners' offer to extend the temporary agreement to the end of January, and it remains to be seen whether the South Wales Miners' Federation decides to report to the Industrial Board that it has again been unable to arrive at an agreement.

LATER.

An emergency meeting of the South Wales Miners' Federation decided on Tuesday last to report to the National Industrial Coal Board that it had been unable to come to an agreement in South Wales and to urge the Board to consider this matter as soon as possible. As the temporary agreement expires on December 31st, the Council asked the Board to give the case a hearing this week or early next week. The Council intends meeting the coalowners at a joint sub-committee meeting on Tuesday next, when it hopes to place the Board's report before the meeting for discussion. This meeting will be followed the same day by a special meeting of the South Wales Miners' Federation Executive Council with a view to calling a coalfield conference at the end of the month.

Coal Trade Suffering.

The continued uncertainty prevailing at home regarding employment conditions in the coalfield, combined with the disturbed conditions existing abroad, are having a very detrimental effect upon coal trade operations. Shipments last week from this district were very disappointing. There was again a falling off, as the total came to only 486,600 tons, as compared with 515,000 tons for the preceding week. Despite the fact that the chartering of tonnage had been on a very fair scale, the tonnage at the disposal of collieries was sadly insufficient towards the end of last week. On Saturday the number of idle tipping appliances came to as many as thirty-six, and there was only one steamer waiting to get into berth, that being at Swansea. Arrivals over the week-end were also not up to expectations, and this week was started with the number of idle tips amounting to twenty-eight. Chartering has also declined since the middle of last week, and it cannot be said that the outlook is at all satisfactory. Foreign inquiry for coals is very restricted, the disturbed conditions prevailing in Spain being altogether against operations so far as shipments to that country are concerned, while in other directions there is a disposition for buyers to look on and watch the developments on this side. The fear that if they enter into purchases of coal they may not get delivery, if there is a stoppage of work, is detrimental to business ahead. The result is that very little is being done either for prompt or forward positions.

Christmas Holidays.

It has been arranged that the official holidays in the coalfield shall be Christmas Day and the following Friday and Saturday. As regards work at the docks, a special meeting of the South Wales Area Trimming Board has also agreed that there shall be no coal loading on the same three days, but that two continuous shifts shall be operated on Christmas Eve. The first is to commence at 6 a.m. and finish at 2 p.m., and the second shall commence at 2 p.m. and finish at 6 p.m. This is a very long break, and will doubtless cause concern to many shipowners. Every effort will, of course, be made by shippers and all concerned to get steamers finished on Wednesday next, so that they can sail, but those which fail to do so will, of course, have to wait in dock until the following Monday to complete their cargoes. This will mean the loss of practically a week, and is an expensive matter for shipowners, considering that they are already losing money, even if their vessels get good despatch, as rates of freight are so unremunerative.

New General Cargo Line.

The arrival at Cardiff this week of the s.s. "San Julian," an American steamer of 6872 tons net register, from the Pacific Coast ports means the inauguration of a new general cargo service. The steamer has brought a large quantity of general cargo, which is being discharged at the Queen Alexandra Dock. The new service is being run by the Pacific-Atlantic Steamship Company, and hopes are entertained that there will be further arrivals from the Pacific Coast.

Tube Works Dispute.

It was thought that work would have been resumed at the Mannesmann Tube Works, Landore, on Monday, but unfortunately such was not the case. This dispute involves 1200 men. Last week a provisional settlement was come to pending arbitration. The management agreed to submit the questions at issue to arbitration and to reopen the works on Monday on the rates and hours of work in operation prior to the stoppage. The men approved and decided to restart work on Monday, after being idle since November 15th. During last week-end, however, allegations were made that the management had contravened the seniority rule in the engagement of men to do preparatory work, and as a result the workmen, instead of returning to work on Monday, held a mass meeting. It was reported to them that a communication received from the company by the divisional officer of the men's organisation intimated that in consequence of interference by the local officials of the men's union with the management of the works and the withdrawal of labour which had been specially provided to make a resumption possible, the works could not be reopened until after the close of the arbitration proceedings.

Current Business.

Although there is now comparatively little business passing on the steam coal market, collieries have very full order books for most qualities for shipment this month. Beyond this year, commitments of collieries are far from satisfactory, as there has been practically no buying for delivery ahead. Some descriptions of large coals are plentiful, but dry qualities are firm, and the same is the case with sized and small coals. Coke shows no change and patent fuel is fairly well stemmed. Pitwood is easier at 27s. to 27s. 6d.

CATALOGUES.

HIGH SPEED STEEL ALLOYS, Ltd., Widnes, Lancs.—"Molybdenum in Steel and Iron."

JOHNSON AND PHILLIPS, Ltd., Charlton, S.E. 7.—A folder on the handling of drums of cable.

CROMPTON PARKINSON, Ltd., Guiseley, Leeds.—Specification No. A 401, "Rotary Converters."

R. WHITE AND SONS, Widnes, Lancs.—"Aerial Ropeways at the Works of S. and E. Collier, Ltd."

HEAD, WRIGHTSON AND CO., Ltd., Norton-road, Stockton-on-Tees.—Details of "Marcus" screen and conveyor.

BERNARD HOLLAND AND CO., 17, Victoria-street, S.W. 1.—Folder on rotary air compressors and vacuum pumps.

HOLDEN AND BROOKE, Ltd., West Gorton, Manchester.—List 544 of pumps, heaters, injectors and steam auxiliaries.

BENJAMIN ELECTRIC, Ltd., Tariff-road, N. 17.—"List 1130," and a copy of "The Reflector," a periodical issued by the firm.

DRAYTON REGULATOR AND INSTRUMENT COMPANY, Ltd., West Drayton, Middlesex.—"Illustrated List of Manufactures."

WESTINGHOUSE BRAKE AND SAXBY SIGNAL COMPANY, Ltd., 82, York-road, N. 1.—A brochure on "Vacuum Servo Braking."

WELDLESS CHAINS, Ltd., 50, Wellington-street, Glasgow.—A folder on various types of lifting dogs, clamps, slings and grabs.

ECO POWER, Ltd., 15, Lincoln's Inn Fields, W.C. 2.—A book giving full details with illustrations and drawings of the Foster economiser.

A. WEST AND PARTNERS, 36, Broadway, S.W. 1.—A 250-page catalogue of drawing, surveying and photographic instruments and materials.

A. J. ASHDOWN, Ltd., 119, Victoria-street, S.W. 1.—Particulars of the Ashdown Rotoscope for the slow-motion study of rapidly moving parts.

ALLOY WELDING PROCESSES, Ltd., Ferry-lane Works, London, E. 17.—"The Welding of Monel Metal and Pure Malleable Nickel," by N. C. Marples.

CARRIER ENGINEERING COMPANY, Ltd., 24, Buckingham Gate, S.W. 1.—"The Carrier-Owen Air Pre-heater and its Application to the Modern Boiler."

BRITISH CATADYN COMPANY, Ltd., Sentinel House, Southampton-row, W.C. 1.—Information regarding a new method of sterilising drinking water.

MATTHEW WYLIE AND CO., Ltd., 81, Portman-street, Kinning Park, Glasgow.—Catalogue No. 130, illustrating and describing the firm's wood box making machines.

W. CANNING AND CO., Ltd., 133, Great Hampton-street, Birmingham.—Leaflets on chrome plating equipment and electric coil heaters for electro-plating solutions.

BAYER SOOT BLOWER COMPANY, Ltd., 125, Balham High-road, London, S.W. 12.—A catalogue of the Bayer steam soot blower, giving details of its construction.

ROYAL INSTITUTION.—The Royal Institution has received an intimation from the Pilgrim Trust that the Trustees have allocated the sum of £16,000 to meet the deficiency on the fund for reconstruction of the Institution. The Trustees state that, in making this grant, they had regard to the distinguished scientific services rendered to the whole community by the Royal Institution for over a century, and to the approaching Faraday celebrations. They were also not unmindful that the founder of the Royal Institution, Count Rumford, was of American origin.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
(1) Native	17/9 to 22/6
(1) Spanish	17/– to 20/–
N.E. COAST—	
Native	18/– to 21/–
Foreign (c.i.f.)	16/–

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	3 17 0	—
No. 1 Foundry	3 19 0	—
No. 3 Foundry	3 16 6	—
N.E. COAST—		
Hematite Mixed Nos.	3 11 0	3 11 0
No. 1	3 11 6	3 11 6
Cleveland—		
No. 1	3 6 0	3 6 0
Siliceous Iron	3 6 0	3 6 0
No. 3 G.M.B.	3 3 6	3 3 6
No. 4 Foundry	3 2 6	3 2 6
No. 4 Forge	3 2 0	3 2 0
Mottled	3 1 6	3 1 6
White	3 1 6	3 1 6
MIDLANDS—		
(c) Staffs.—	(*Delivered to Station.*)	
All-mine (Cold Blast)	—	—
North Staffs. Forge	3 6 0	—
,, ,, Foundry	3 11 0	—
(c) Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
(3) Lincolnshire—		
No. 3 Foundry	—	—
No. 4 Forge	—	—
Basic	—	—
(4) N.W. COAST—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 3 6 (*a*) / 4 5 6 (*b*) / 4 10 6 (*c*)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	10 5 0	9 15 0
Best	—	—
N.E. COAST—		
Iron Rivets	11 10 0	—
Common Bars	10 15 0	—
Best Bars	11 5 0	—
Double Best Bars	11 15 0	—
Treble Best Bars	12 5 0	—
LANCS.—		
Crown Bars	10 5 0	—
Second Quality Bars	8 15 0	—
Hoops	13 0 0	—
S. YORKS.—		
Crown Bars	10 5 0	—
Best Bars	11 0 0	—
Hoops	12 0 0	—
MIDLANDS—		
Crown Bars	10 0 0 to 10 7 6	—
Marked Bars (Staffs.)	12 10 0	—
Nut and Bolt Bars	9 0 0 to 9 5 0	—
Gas Tube Strip	10 17 6 to 11 0 0	—

STEEL. (*d*)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates (Marine)	10 10 0	10 10 0
,, ,, (Land)	10 0 0	10 0 0
Ship Plates, ½in. and up	8 15 0	7 15 0
Sections	8 7 6	7 7 6
Steel Sheets, ¼in.	8 15 0	8 15 0
Sheets (Gal. Cor. 24 B.G.)	11 7 6	11 5 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	8 15 0	7 15 0
Angles	8 7 6	7 7 6
Boiler Plates (Marine)	10 10 0	—
,, ,, (Land)	10 0 0	—
Joists	8 10 0	7 7 6
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5s.
Hard Billets	8 2 6	—
Soft Billets	6 17 6	—
N.W. COAST—		
BARROW—		
Heavy Rails	8 10 0	—
Light Rails	8 15 0 to 9 0 0	—
Billets	6 15 0 to 9 10 0	—
MANCHESTER—		
Bars (Round)	9 7 6	—
,, (Small Round)	7 7 6	—
Hoops (Baling)	10 0 0	9 15 0
,, (Soft Steel)	9 0 0	8 15 0
Plates	8 17 6 to 9 2 6	—
,, (Lancs. Boiler)	9 7 6	—
SHEFFIELD—		
Siemens Acid Billets	9 10 0 (basic)	—
Hard Basic	9 2 6 and 9 12 6	—
Intermediate Basic	7 12 6 and 8 2 6	—
Soft Basic	6 5 0	—
Hoops	10 5 0	—
Soft Wire Rods	7 10 0	—
MIDLANDS—		
Small Rolled Bars	7 7 6 to 8 5 0	—
Billets and Sheet Bars	5 12 6 to 6 10 0	—
Galv. Sheets, f.o.b. L'pool	11 5 0	—
(2) Staffordshire Hoops	10 0 0	—
Angles	8 7 6	—
Joists	8 10 0	—
Toes	9 7 6	—
Bridge and Tank Plates	8 17 6	—
Boiler Plates	9 7 6 to 9 10 0	—

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14 f.o.b.	15/9 to 16/–
Block Tin (Cash)	105 10 0
,, (three months)	106 15 0
Copper (cash)	44 5 0
,, (three months)	44 1 3
Spanish Lead (cash)	14 17 6
,, ,, (three months)	14 17 6
Spelter (cash)	13 6 3
,, (three months)	13 6 3
MANCHESTER—	
Copper, Best Selected Ingots	47 10 0
,, Electrolytic	49 10 0
,, Strong Sheets	80 0 0
,, Tubes (Basis Price), lb.	0 0 11½
Brass Tubes (Basis Price), lb.	0 0 10
,, Condenser, lb.	0 1 0½
Lead English	16 5 0
,, Foreign	14 17 6
Spelter	13 17 6
Aluminium (per ton—raw ingot)	£95

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	2/6 per lb.	
Ferro Tungsten	2/3 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 5 6	7/–
,, ,, 6 p.c. to 8 p.c.	£22 10 0	7/–
,, ,, 8 p.c. to 10 p.c.	£22 0 0	7/–
,, ,, Specially Refined		
,, ,, Max. 2 p.c. carbon	£33 0 0	10/–
,, ,, ,, 1 p.c. carbon	£38 0 0	13/–
,, ,, ,, 0·70 p.c. carbon	£41 0 0	14/–
,, ,, ,, carbon free	11d. per lb.	
Metallic Chromium	2/7 per lb.	
Ferro Manganese (per ton)	£11 15 0 for home	
,, ,, ,,	£11 5 0 for export	
,, Silicon, 45 p.c. to 50 p.c.	£11 10 0 scale 5/– per unit	
,, ,, 75 p.c.	£18 0 0 scale 7/– per unit	
,, Vanadium	12/9 per lb.	
,, Molybdenum	4/2 per lb.	
,, Titanium (carbon free)	10d. per lb.	
Nickel (per ton)	£170 to £175	
Ferro Cobalt	9/6 per lb.	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	13/6
,, ,, Ell	15/–
,, ,, Splint	15/6 to 16/6
,, ,, Trebles	14/– to 14/6
,, ,, Doubles	13/3 to 13/6
,, ,, Singles	12/9 to 13/–
AYRSHIRE—	
(f.o.b. Ports)—Steam	13/–
,, ,, Jewel	18/–
,, ,, Trebles	14/–
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Steam	12/– to 13/6
Screened Navigation	16/6 to 17/6
Trebles	14/6 to 16/6
Doubles	13/–
Singles	12/6 to 13/–
LOTHIANS—	
(f.o.b. Leith)—Best Steam	12/6
Secondary Steam	12/–
Trebles	13/6 to 14/6
Doubles	12/6 to 12/9
Singles	12/6

ENGLAND.

(8) N.W. COAST—	
Steams	20/6 to 21/–
Household	32/6 to 53/6
Coke	21/– to 22/–
NORTHUMBERLAND—	
Best Steams	13/9 to 14/3
Second Steams	13/– to 13/3
Steam Smalls	10/– to 10/6
Unscreened	12/6 to 13/–
Household	25/– to 37/–
DURHAM—	
Best Gas	15/–
Second	13/6
Household	25/– to 37/–
Foundry Coke	24/– to 26/–
SHEFFIELD—	Inland.
Best Hand-picked Branch	25/6 to 27/– —
Derbyshire Best Bright House	20/– to 22/6 —
Best House Coal	20/6 to 21/6 —
Screened House Coal	18/– to 19/– —
,, ,, Nuts	15/6 to 16/6 —
Yorkshire Hards	14/– to 15/6 —
Derbyshire Hards	14/– to 15/6 —
Rough Slacks	8/6 to 9/– —
Nutty Slacks	6/6 to 7/– —
Smalls	3/– to 5/– —
Blast-furnace Coke (Inland)	11/– on rail at ovens
Furnace and Foundry Coke (Export), f.o.b. 15/6 to 16/–	

(9) SOUTH WALES.

CARDIFF—

Steam Coals:	
Best Smokeless Large	20/–
Second Smokeless Large	18/9 to 19/9
Best Dry Large	18/6 to 19/–
Ordinary Dry Large	17/6 to 18/–
Best Black Vein Large	18/3 to 18/6
Western Valley Large	18/– to 18/3
Best Eastern Valley Large	17/7½ to 17/9
Ordinary Eastern Valley Large	17/6 to 17/7½
Best Steam Smalls	13/3 to 13/9
Ordinary Smalls	11/6 to 12/9
Washed Nuts	17/6 to 22/6
No. 3 Rhondda Large	20/– to 20/6
,, ,, Smalls	15/6 to 16/–
No. 2 ,, Large	17/– to 17/3
,, ,, Through	16/– to 16/6
,, ,, Smalls	14/– to 14/3
Foundry Coke (Export)	27/6 to 35/–
Furnace Coke (Export)	17/6 to 20/–
Patent Fuel	21/6
Pitwood (ex ship)	27/3 to 27/6
SWANSEA—	
Anthracite Coals:	
Best Big Vein Large	35/– to 37/6
Seconds	27/– to 31/6
Red Vein	23/6 to 27/–
Machine-made Cobbles	41/6 to 45/–
Nuts	40/– to 46/–
Beans	24/6 to 28/–
Peas	20/3 to 21/6
Breaker Duff	9/9 to 10/3
Rubbly Culm	9/– to 9/6
Steam Coals:	
Large	19/6 to 21/6
Seconds	18/– to 19/6
Smalls	12/– to 13/–
Cargo Through	15/6 to 16/–

(1) Delivered. (2) Net Makers' Works. (3) f.o.b. Makers' Works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire, and Ayrshire. (6) Home Prices—All delivered Glasgow Station. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham. (*d*) Rebate: Joists (minimum), 12/6: Ordinary Ship, Bridge, and Tank Plates and Sections, 10/– if home consumers confine purchases from associated British Steel Makers. (*e*) Delivered Black Country Stations.

French Engineering Notes.

(From our own Correspondent in Paris.)

Steel Production.

THE meeting of the Steel Cartel in Paris was unable to settle the various questions that stand in the way of a renewal of that body, and it was therefore decided to prolong it for another six months from December 31st in order to give time for a solution of the difficulties. The chief of these difficulties is to provide for minimum prices for export and the distribution of foreign orders. That was to have been done by the International Sales Comptoir, which, however, was unable to continue its work through failure of support from Belgian and German steel producers who were not satisfied with the method of distribution. The reduction in the steel output during the first quarter of next year has been increased from 25 to 30 per cent. of the production for October, 1929, or, as an alternative, members of the Cartel may adhere to quotas on the old basis of production during October, 1926. France and Belgium are favoured by this latter arrangement; but, in any case, the French monthly steel output will be considerably reduced, probably by some 150,000 tons. There will be a more rigid enforcement of penalties for excess of production, which are fixed at 4 dollars a ton for export and 1 dollar per ton for home consumption. The negotiations for renewing the Cartel have been continued for some months against almost insuperable obstacles, but there is now a general impression that the task of conciliating the interests of steel makers in different countries, and reorganising the Cartel on a stable basis, will be carried through to a successful issue. Meanwhile, the steel trade would be safe from indiscriminate price cutting for foreign business during the next six months if it were not for the diminishing home consumption, which leaves larger quantities of steel for export; but continental producers have found that there is no advantage in disposing of their steel abroad at barely over cost when they cannot get sufficiently high prices at home. The efforts of Czecho-Slovakian steel makers to cover low prices for export by quoting high prices at home have been countered by the Government threatening to reduce the import duty on steels by 50 per cent. unless home prices are reduced.

Wreck Explosion.

The loss of the Italian salvage steamer "Artiglio" with twelve of the crew and two divers through the explosion of munitions in a sunken wreck between Belle-Ile and the mainland was due to the belief that the munitions had been rendered harmless by their long immersion under the sea. In 1917 the American cargo boat "Florence" arrived off Belle-Ile with a considerable load of munitions. A cable message had been received from New York, stating that a bomb had been placed on board timed to explode when the steamer had docked at Saint-Nazaire. The "Florence" was therefore left in the Quiberon Bay and abandoned. The following day she blew up. As the wreck was a hindrance to navigation, the salvage steamer "Artiglio," a Glasgow-built boat of 311 tons, belonging to the Recuperi Maritimi Sorima, of Genoa, was engaged to blow up the wreck. The "Artiglio" was equipped with the most modern salvage appliances and had already done useful work in recovering a cargo of ivory from the "Elisabethville," which had sunk off the coast, and it had raised the safe from the captain's cabin in the liner "Egypt," which had foundered with a large quantity of bullion. Operations on the liner were interrupted by bad weather, and the salvage steamer returned to Brest. Meanwhile, expert opinion declared that there was nothing to fear from the 200 tons of munitions which remained in the after part of the "Florence." The "Artiglio" therefore sent down divers to attach mines to the wreck, and the steamer fired them from a distance of less than 300 yards. The mines exploded the munitions. The "Artiglio" was drawn into the vortex and disappeared. Only a few survivors were picked up.

The Lyons Air Port.

The Lyons Chamber of Commerce has completed the air port at Lyon-Bron, which was undertaken in accordance with the plan to make that city a centre of air traffic on the line between Paris and Marseilles and, more especially, between the port of Bordeaux and Central Europe. So far as the transversal traffic is concerned, the results are far from coming up to expectations. The attempt to organise a line between Bordeaux and Geneva failed, and nothing has yet been done with the proposal to radiate national lines from Lyons and other centres. It is, therefore, impossible to foresee in what way the air services affecting Lyons will develop in the future, but the new air port has been laid out to meet all emergencies, with a block of buildings for the convenience of passengers, goods and air services, including even hotel accommodation. The building has a circular pagoda with three storeys terminating at the top in a lookout tower. Joining the pagoda are two blocks at right angles, with three storeys shortening one above the other. The building is constructed of reinforced concrete with large bays and glass floors, which make the structure airy and light.

Colonial Anthracite.

The anthracite deposits in Tonkin outcrop over a distance of 95 miles, and they are nearly all quarried at the surface. There is little local demand for the fuel, though a million and a-half tons are sent to China and Japan yearly, and a good deal is employed for the manufacture of composite fuel. So low is the cost of production that the three French companies mining the anthracite are looking to markets abroad. Trial consignments have been made to the United States, and in a report issued by one of the Tonkin colliery companies it is stated that 20,000 tons of anthracite have been sent to Rouen, following upon which orders have been received from France, Switzerland, Belgium and Italy for a total of 75,000 tons. This is a comparatively small amount, but it only represents the business done by one company in its initial efforts to introduce anthracite from Tonkin into continental markets.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

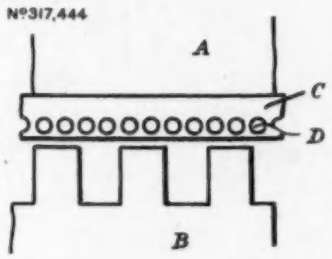
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

DYNAMOS AND MOTORS.

317,444. August 1st, 1929.—ELECTRICAL MACHINES, Torsten Johan Nilsson-Stig, of Umea, Sweden.

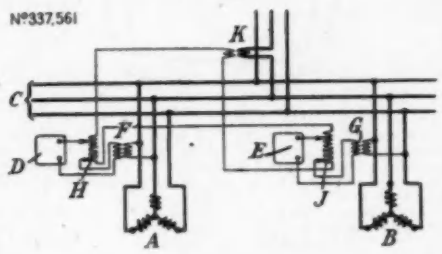
This invention has for its object to ensure to electrical machines, generators, motors, or converters, appreciably reduced iron losses, whereby the efficiency may in certain cases be improved. The characteristic feature of the invention resides in that the armature windings are, wholly or partly, inserted into a rigid former or frame of insulating material between the magnetically active parts of the machine. Thus the air gap will be



increased, and in consequence the machine requires more powerful excitation. The construction will therefore show to the best advantage in types of machines in which the iron losses are great in relation to the losses of excitation. This is particularly the case in A.C. machines with a higher periodicity than that of the common systems of power transmission. A and B are the magnetically active parts of the machine. C is a former or frame of insulating solid material and D the armature windings.—*November 3rd*, 1930.

337,561. October 10th, 1929.—ELECTRIC POWER STATION SYSTEMS HAVING AUTOMATIC VOLTAGE REGULATION, Allmänna Svenska Elektriska Aktiebolaget, of Västeras, Sweden.

According to this invention, electric power station systems having several generators feeding an outgoing line and provided with automatic voltage regulators influenced, not only by the generator voltage, but also by the voltage of compounding impedances traversed by currents proportional to the load currents, are arranged so that each voltage regulator is connected in series with an individual compounding impedance and all of such impedances are traversed by currents proportional to the current in the line. Two generators A and B operate on a bus-bar system C, and each generator is provided with an auto-

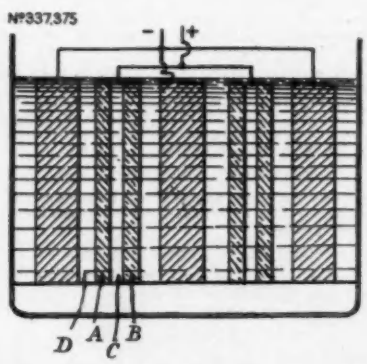


matic voltage regulator D and E respectively, the connections between the regulators and the exciting windings of the generators not being shown. Each regulator is influenced by a voltage compounded by the voltage from a potential transformer F or G respectively and the voltage from a compounding impedance H or J respectively. These impedances are traversed in series by the current from a current transformer K connected in the outgoing line. The voltage regulators are preferably connected to regulating taps on the impedances, whereby the compounding can be altered at will for keeping the voltage constant at any desired point of the line by regulating the magnitude of the impedance. In order to adapt the impedance to varying line conditions the phase angle of the impedance, *i.e.*, the proportion between ohmic resistance and inductance, may also be capable of being regulated.—*November 6th*, 1930.

BATTERIES AND ACCUMULATORS.

337,375. April 29th, 1929.—ELECTRIC ACCUMULATORS, Société Anonyme des Accumulateurs-Monoplaque, of 77 to 83, Boulevard Marceau, Colombes, Seine, France.

According to this invention, each positive plate in an ordinary

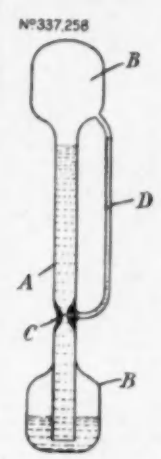


accumulator is replaced by a group of two plates A B of reduced thickness, kept at a suitable distance apart and having between them a space C. The sulphuric acid in the space C between the positive plates A B tends to preserve its concentration, while that between the positive and negative plates in the spaces D tends, on the contrary, to disappear. Each positive plate is therefore subjected (1) to a hydrostatic pressure, and its speed of filtration under the influence of this force is directly proportional to its porosity, and to the square of the capillary tubes, which may be made very large; and (2) to an electro-osmotic pressure which is of the form $P = K E$, K being a constant and E being the fall of potential from one side to the other of the positive plate. As the differences of concentration of the electrolyte on the two sides of each positive plate tend to increase on discharge with the output of the accumulator, the hydrostatic and electro-osmotic pressures also tend to increase and also, in consequence, the speed of filtration. Each positive plate, such as A B, may thus be given a much smaller thickness than that which would be given to a simple plate. Even if each element of the plate had only for an equal surface half the thickness of a normal plate, the capacity of the double plate thus obtained would be greater than that of a single plate of double thickness.—*October 29th*, 1930.

MEASURING AND TESTING INSTRUMENTS.

337,258. December 9th, 1929.—APPARATUS FOR THE STUDY OF VIBRATIONS, P. F. E. Piette, 29, Rue du Moulin de Pierres, Clamart (Seine), France.

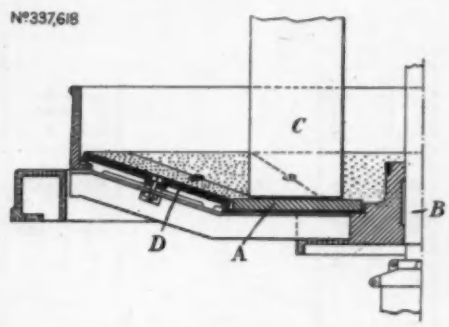
With the object of studying the intensity of vibrations of machinery the inventor proposes the use of an instrument, one embodiment of which we illustrate. It takes the form of a tube A, connected with two chambers B B and partly filled with a liquid. In the length of the tube there is a Venturi orifice C, connected with a manometer tube D. If the apparatus is subjected to vertical vibrations the height of the liquid in the manometer tube will be a measure of the amplitude of those vibrations. Corresponding arrangements can be made for measuring vibrations in other directions.—*October 30th*, 1930.



CRUSHING AND GRINDING.

337,618. November 18th, 1929.—GRINDING PANS, J. Drysdale, Balmaha, Oakwood Park, Roundhay, Leeds; and A. E. Bottomley, 50, Copgrove-road, Leeds.

In this pan mill there is an annular grinding surface A rotated on the vertical spindle B, on which there roll one or more rolls C.

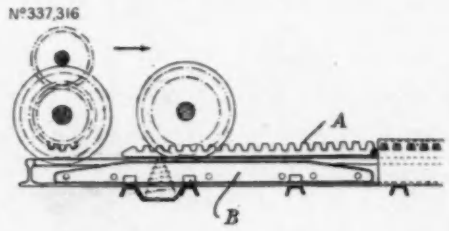


Beyond the face A there is a sloping perforated floor D, on to which the ground material is thrown by centrifugal force. The material which has been ground sufficiently fine falls through this grid. Constructional details are given in the specification.—*November 6th*, 1930.

TRAMWAYS AND RAILWAYS.

337,316. February 11th, 1930.—RACK RAILWAYS, J. Buchli, 33, Hermannstrasse, Winterthur, Switzerland.

On rack railways in which there is a combination of rack and adhesion traction, there is sometimes some difficulty in meshing the driving pinion of the locomotive with the rack, and endeavours are made to overcome this trouble by the introduction of a hinged and spring-supported piece of rack, as shown



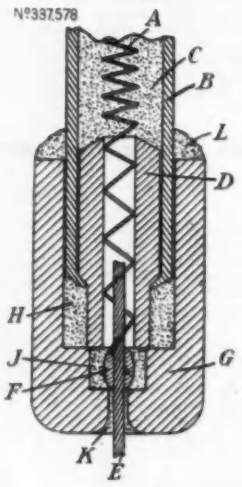
at A. Even then, however, there is a tendency for the pinion teeth to ride right along on the top of the teeth of the rack. The inventor overcomes this difficulty by providing a ramp B, on which the flanges of the adhesion wheels ride. The result is that there is a relative peripheral movement between the wheels and the pinion, which, the inventor says, will ensure engagement within ten teeth.—*October 30th*, 1930.

LIGHTING AND HEATING.

337,578. October 15th, 1929.—ELECTRIC HEATING ELEMENTS, Charles Sykes, of 12, Derbyshire-lane, Stretford, Manchester; Rowland Graves Alger, of 87, Grosvenor-road, Urmston, Manchester; and Associated Electrical Industries, Ltd., of Bush House, Aldwych, Westminster.

This invention relates to electric heating elements and concerns particularly elements of the kind in which a spirally-coiled resistance wire is sheathed in a metal tube from which it is

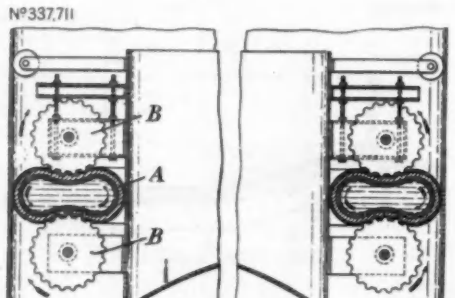
insulated. A spirally coiled resistance wire A is sheathed in a metal tube B from which it is insulated by an insulating substance, such, for example, as magnesium hydroxide, C. The end of the resistance wire passes out from the tube B through a plug D of steatite or similar material, and beyond the end of the plug is brazed or silver soldered to the terminal wire E, as indicated at F. A cap G of steatite is threaded on the terminal wire E and receives the end of the metal tube B and also covers over the brazed or soldered joint F, being provided with recesses of suitable size for these purposes. The cap G is cemented to the



tube B as indicated at L, and the recesses within the cap at the end of the tube B and surrounding the joint F and the terminal wire E are also filled with cement, as indicated at H, J and K respectively. In the particular form shown it will be observed that the insulating plug has a reduced outer end portion, and that the end of the tube B is turned in over the shoulder thus formed. This is a convenient construction, but is not essential. The space between the end of the metal tube and the cap may also be very much smaller than as shown in the drawing, and other variations in the size and dimensions of the parts may be made without transgressing the limits of the invention.—*November 5th*, 1930.

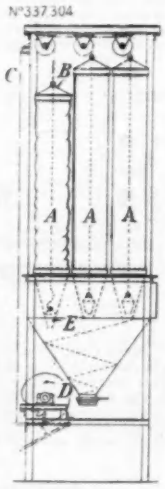
337,711. March 3rd, 1930.—A DRY SEAL FOR DISC GASHOLDERS, E. Chur, 77, Krefelderstrasse, Cologne, Germany.

This seal for a waterless gasholder takes the form of a flexible, jointless hose A, which is filled with air or other fluid and is



pressed against the sides of the gasholder by the wooden rollers B B. The upper set of these rollers is mounted in adjustable brackets, so that the pressure on the hose can be regulated.—*November 6th*, 1930.

MISCELLANEOUS.

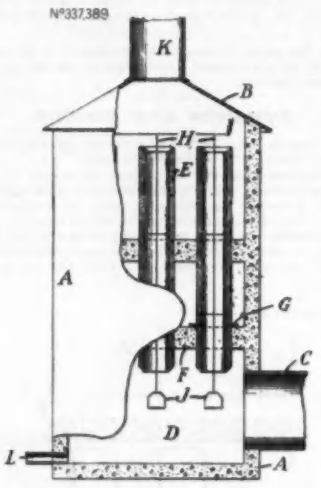


337,304. January 30th, 1930.—DUST FILTERS, W. M. Oddie, Thorniehurst, Shaw-lane, Headingley, Leeds.

This invention is concerned with the extraction of dust from air by means of filtration through fabric bags. The bags are shown at A A A, and are supported by covers B and chains C. These chains are connected with a cam gear D, which periodically collapses one or other of the bags. At the same time a plug E drops into the inlet of the bag, and temporarily prevents the ingress of any more air. The dust accumulated on the fabric then falls to the bottom of the bag, and is discharged abruptly when the bag is distended again.—*October 30th*, 1930.

337,389. July 29th, 1929.—COLLECTING ELECTRODE FOR ELECTROSTATIC PRECIPITATORS, National Carbon Company, Inc., of 30, East Forty-second-street, New York.

The invention relates to electrostatic precipitators of the kind in which fluids bearing suspended liquid or solid particles are caused to pass through an electrostatic field to precipitate the suspended particles. The precipitator shown comprises side and bottom walls A and a roof B. A conduit C supplies gas containing suspended matter—for example, air carrying phosphoric and aqueous hydrofluoric acids. The gas and suspended matter pass into the manifold D and thence into the tubular precipitating chambers E. The tubes E pass through the lower wall F, which forms the top of the manifold and may be supported on this wall by split rings G engaging grooves in the tubes. The tubes E consist of sections having interfitting bevelled ends and are additionally supported at appropriate points. The central con-



ductors are shown at H and may take the form of wires carrying weights J to hold them taut. The clean gases escape at K, while the acids precipitated are discharged through pipe L. Carbon tubes made by the usual extruding and baking process ordinarily have a sufficiently smooth and regular surface. If greater accuracy is desired, tubes may be machined from solid or perforated blocks of carbon.—*October 29th*, 1930.

338,092. March 21st, 1930.—THE PRODUCTION OF COMPOSITE METAL CASTINGS, W. Alberts, Kanzlerstrasse 21, Duisburg-Ruhrort, Germany; and F. Stein, Siegfriedstrasse 37, Duisburg-Meiderich, Germany.

This invention is concerned with the production of ingots or billets for the manufacture of such objects as railway metals, in which it is desired to have a comparatively hard wearing surface with a soft support. It is suggested that such ingots

can be made by pouring into the mould the two qualities of metal, while they are separated by a partition that should amalgamate into the whole mass. The inventors say that such a process has not been found satisfactory on account of the lack of adhesion of the two parts of the ingot. By means, however, of using a partition having, say, 99·8 per cent. of Fe between the two sections of the mould, they claim that complete interfusion is effected.—*November 13th*, 1930.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

TO-DAY.

CRYSTAL PALACE SCHOOL OF PRACTICAL ENGINEERING.—174th award of certificates. Mr. C. P. Sandberg will take the chair at 3 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, S.W. 1. Informal meeting. "Well Drill Blasting," by Mr. W. Cullen. 7.30 p.m.

LONDON SOCIETY.—In the Hall of the Royal Society of Arts, John-street, Adelphi, London, W.C. 2. "South Essex: Its Docks, Industries and House: London's Industrial Development," by Professor Adshead. 5 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Bolbec Hall, Newcastle-upon-Tyne. Informal meeting in the Institution Library. Discussion, "Are We Justified in Using Steel and Other Materials of Foreign Manufacture in the British Engineering Industries?" to be introduced by Mr. E. Leslie Champness. 7.15 p.m.

SATURDAY, DECEMBER 20TH.

INSTITUTION OF CIVIL ENGINEERS.—Student's visit to the Stratford Works of the London and North-Eastern Railway Company in the afternoon.

MONDAY, DECEMBER 22ND.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Institution of Engineers and Shipbuilders, 39, Elmbank-crescent, Glasgow, "Trends in the Transmission," by Dr. H. E. Merritt. 7.30 p.m.

THURSDAY, DECEMBER 25TH.

CHRISTMAS DAY.

TUESDAY, DECEMBER 30TH.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Christmas lectures: (i) "The Electric Spark: Some Properties of Electrified Bodies," by Professor A. M Tyndall. 3 p.m.

1931.

THURSDAY, JANUARY 1ST.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Christmas lectures: (ii) "The Electric Spark: The Spark as a Current of Electricity," by Professor A. M. Tyndall. 3 p.m.

FRIDAY, JANUARY 2ND.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, St. James's Park, London, S.W. 1. Extra general meeting. "An Experimental Investigation into Induction Conditions, Distribution, and Turbulence in Petrol Engines," by Mr. S. J. Davies. 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, S.W. 1. Informal meeting. "Weighing Machinery," by Mr. W. A. Benton. Illustrated by slides and exhibits. 7.30 p.m.

SATURDAY, JANUARY 3RD.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Christmas lectures: (iii) "The Electric Spark: Air as a Conductor of Electricity," by Professor A. M. Tyndall. 3 p.m.

TUESDAY, JANUARY 6TH.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Christmas lectures: (iv) "The Electric Spark: The Mechanism of a Spark and Other Forms of Discharge," by Professor A. M. Tyndall. 3 p.m.

THURSDAY, JANUARY 8TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—The Merchant Venturers' Technical College, Unity-street, Bristol. "Light Alloy Piston Development," by Mr. E. V. Pannell. 7 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Christmas lectures: (v) "The Electric Spark: Some Properties of Sparks and Arcs," by Professor A. M. Tyndall. 3 p.m.

FRIDAY, JANUARY 9TH.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, S.W. 1. "Monel Metal: Some Notes on its Production and Industrial Application," by Mr. J. Doonan. 7.30 p.m.

SATURDAY, JANUARY 10TH.

INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—At the Grand Hotel, Manchester. Annual dinner. 6.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Christmas lectures: (vi) "The Electric Spark: Large Sparks," by Professor A. M. Tyndall. 3 p.m.

FRIDAY, JANUARY 16TH.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, S.W. 1. Informal meeting. Lecture, "Some Problems Surrounding the Reorganisation of an Engineering Works," by Mr. K. W. Willans. 7.30 p.m.

NATIONAL CONFERENCE ON INDUSTRIAL MECHANISATION.—Hotel Metropole, London, W.C. 2.

MONDAY, JANUARY 26TH.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. Cantor Lecture: "Some Modern Developments in Microscopy," by Dr. L. C. Martin. 8 p.m.

WEDNESDAY, JANUARY 28TH.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. "The Restoration of St. George's Chapel, Windsor Castle," by The Very Rev. Albert Baillie, Dean of Windsor. 8.30 p.m.

WEDNESDAY, FEBRUARY 18TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—The Engineers' Club, Albert-square, Manchester. "Light Alloy Piston Development," by Mr. E. V. Pannell. 7 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS

THE POWER PLANT CO., Ltd., of West Drayton, Middlesex, asks us to announce, that Mr. G. H. Harrison, of "Hazelmere," Knoll Avenue, Swansea, has been appointed its agent for the South Wales district.

THE name of the Hardy Patent Pick Company, Ltd., of Sheffield, has been altered to Hardypick, Ltd. The telegraphic and cable address—"Hardypick, Sheffield"—and telephone numbers—Sharrow 51045 and 51046—are unaltered.

THE BRITISH ROPEWAY ENGINEERING COMPANY, Ltd., asks us to announce that it has changed its offices from 14, Holborn, E.C. 1, to 14–18, High Holborn, London, W.C. 1, and requests that all future correspondence shall be sent to it at the latter address.

THE NATIONAL FIRE BRIGADES' ASSOCIATION asks us to announce that on and after December 20th, 1930, the address of its head office will be 1, Montague-street, Bloomsbury-square, London, W.C. 1. Telegrams, Firebrief-Westcent; telephone, Museum 4800.

HIS MAJESTY THE KING has approved the award of the Royal Gold Medal for Architecture to Sir Edwin Cooper, A.R.A., F.R.I.B.A., in recognition of the merit of his executed work. The Medal will be presented to Sir Edwin Cooper on Monday, March 2nd, 1931.

WE are asked to announce that an arrangement has been made between Edgar Allen and Co., Ltd., Imperial Steel Works, Sheffield, and the Allis-Chalmers Manufacturing Company, Milwaukee, U.S.A., under which the former will manufacture at Sheffield and sell in certain parts of the British Empire and Asia various types of Allis-Chalmers crushing and grinding machinery. The arrangement does not apply to Canada and the sales organisation of the Allis-Chalmers Manufacturing Company in Paris, London and South Africa will not be affected in any way.

SHIELDED ARC WELDING.—A further developing of the shielded arc welding process, which brings it still nearer to every-day use by non-specialists, has been reported. The process has been simplified, by adopting hand welding—the welder holds the bare electrode in the right hand and a gas torch in the left—and cheapened, by using "cracked" ammonia in place of hydrogen for the gas shield. The cracked ammonia is cheaper because the ammonia itself, when in the liquid state, occupies a smaller bulk in transport than compressed gas, and it is "cracked" at low pressure in an electrically heated tube containing a catalyst. The process was developed originally by the General Electric Company of America, for automatic and semi-automatic welding, but these later developments have been made in this country. The process, it is claimed, can now be definitely regarded as beyond the experimental stage.